Australian Society of Exploration Geophysicists

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PREVIEW

NEWS AND COMMENTARY

There will never be a New Normal

Going back to school in 2021

Future trends in environmental geophysics

FEATURES

Biological geomagnetic field sensing

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ASEG CORPORATE PLUS MEMBER

ASEG CORPORATE MEMBERS

FRONT COVER

Matthew Shrimpton from the University of Melbourne acquiring gravity data for his thesis project. See *Education matters* in the December 2020 issue of Preview for more information.

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Editor's desk

Many members of the *Preview* family will have been distressed to hear of the death of Richard Lane. The news certainly dropped me into a Slough of Despond. We will celebrate Richard's life in the next issue of *Preview* and, most importantly, we will be publishing the paper on which Richard was working, with Des Fitzgerald, at the time of his death.

The production of the last issue of *Preview* was disrupted by a cyclone in Chennai, India, where the typesetters live and work. The production of this issue was disrupted by a cyclone in Far North Queensland – where I live and work. Fortunately Cyclone Kimi only skirted the coast line, but it did deliver a lot of rain. Three weeks into the New Year and we have already had nearly a fifth of our total average annual rainfall (over half a metre relative to our average of nearly three metres). Small beer in the global scheme of things, but one rather wonders what else 2021 will deliver!

In this issue of *Preview* Roger Henderson entertains us with an article on "Biological geomagnetic field sensing". However, David Denham (*Canberra observed*) brings us back to earth with a bump by opining that a New Normal in 2021 is just not possible. He knocks another nail in the coffin by reminding us that government expenditure on R&D in Australia is woefully inadequate. Our new Associate Editor for Education Marina Pervukhina (*Education matters*) does offer those of us uncertain about our future a ray of hope in terms of opportunities available for up-skilling or re-skilling. Mike Hatch (*Environmental geophysics*) surveys some of his colleagues about the state of play in environmental geophysics and makes some bold predictions. Terry Harvey (*Mineral geophysics*) reflects on the impact of the Australian land surface on geophysical survey design. Mick Micenko (*Seismic window*) considers the application of seismic methods to hard rock terrains. Tim Keeping (*Data trends*) revisits point gridding with some handy code, and Ian James (*Webwaves*) guides us through accessing cached webpages.

Happy New Year to you all (and my fingers are very firmly crossed)!!

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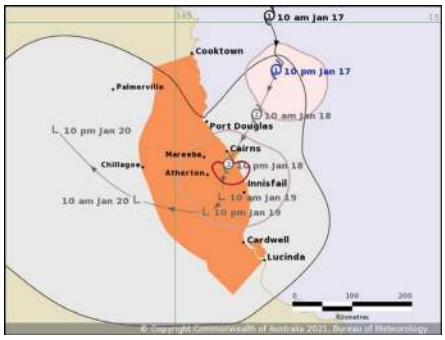

Nothing like waking to find a cyclone is forecast to track right over your house.

Letter to the Editor

Dear Lisa

I enjoyed Don's article on divination in *Preview* very much. I need to read it several times more to get a grasp of all the detail. It was an amazing piece of research. Well done.

On many occasions I have discussed the veracity of the diviners' art with Bob White, who insists that there is something in it. I am an arch sceptic. Next time we get in a discussion I will have a trusted reference to turn to in order to back up my arguments. Thanks.

As technical chair for the Sydney AEGC a few years ago, I was asked to send in a fake abstract to test the submission system. I wanted to make it geophysical but nothing too serious. One night after a glass of red wine or two, I decided to write a poem about divining (being sort of geophysics). Many many hours later in the early morning and after several more glasses of red, I finished and submitted it to the AEGC abstract system. I then fell into bed.

Several hours later I awoke with a headache and a dreadful sense of embarrassment. Like emails written after wine consumption, abstracts should not be submitted until one's head has cleared in the light of day.

The lady in the professional conference organisers' office emailed me the next day to say that the poem had done the rounds of their office and they had had a good laugh and all appreciated the change from dry old abstracts normally submitted. When I reread it I decided that it wasn't so bad - for an amateur.

I have attached a copy. I hope this will make you smile at the end of this otherwise dreary year.

Steve Collins
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Groundwater geophysics

A drought had struck the very heart
Of this our mighty nation.
And young Bruce Jones was feeling ill
Quite full with consternation.
His problem was embarrassment
That caused him hesitation
To use the loo and so resulted
Stage three constipation.

The farmhouse bore had dried right up
The water never came.
And so the toilet would not flush
When poor Bruce pulled the chain.
This country boy was very shy
He couldn't stand the shame.
And so he stood with legs held close
I thought him quite insane.

His family sat by quite concerned
About his lonely plight.
They begged him, 'Do it anyway'
For two days and a night.
But still he held for fear or shame
His legs together tight.
Their pleas all fell on his deaf ears
He gripped with all his might.

Just when the problem got extreme
With Bruce's null ablution.
An old man turned up at the door
Who claimed a good solution.
'I'll fix the problem in a flash
I'll fix his constitution.
I'll find some water here and now
For this fine institution'.

And so he strode across the fields
A bent wire out in front.
His gaze was fixed on ground ahead
In this his water hunt.
At last he stopped. He made a smile
And gave a mighty grunt.
'There's water here' he cried out loud.
I thought it was a stunt.

We dug down deep upon that spot
And made a brand new well.
The water came two metres down.
Or more. It's hard to tell.
But came it did, the walls got wet
It even had the smell
Of moisture seeping in the hole.
My doubts it did dispel.

We quickly got a small red pump
And lots of piping too.
We ran a line from our new well
Directly to the loo.
And in we pushed, reluctant Bruce
He knew just what to do.
With cistern full at last he could
Relieve his need to poo.

An hour passed and then one more
Before we heard a sound.
The sigh that echoed from the loo
Was really quite profound.
And then the sound of falling water
Contents all were drowned.
And all the cause of Bruce's pain
Was flushed straight underground.

Then Bruce emerged in boisterous stride
With joy and jubilation.
The water dowser's clever skill
Removed his tribulation.
Then we all thanked the visitor
And gave him an ovation.
When drought returns, we'll turn for sure
*To using divinat*ion.

(Or resistivity, or EM, or even SP).

President's piece

I take this opportunity to wish ASEG Members, their families, our corporate partners and affiliate societies a joyous, healthy and prosperous New Year. It is with a great sense of optimism that I pen my first President's Piece for 2021.

Last year seemed to lob disaster after disaster at us. Fires across Australia, Africa and the USA. Floods across Asia. And a worldwide pandemic that meant that the terms 'lock down' and 'social distancing' entered our vocabulary. As the world breathed a collective sigh of relief at the development of a vaccine, COVID-19 appears to have mutated at least twice to welcome the New Year.

From another perspective, perhaps the only extraordinary thing about the 'extraordinary events' of 2020 was their magnitude. Bush fires, even large bush fires, have occurred previously. Pandemics have also affected the world to varying degrees; regionally, for example in the case of SARS (2002-03) and MERS (2012), and globally in the case of the Spanish flu (1918). Even the political crisis in the USA, which is still playing out at the time of writing, has precedents. Samuel Clemens (aka Mark Twain) has said that "history doesn't repeat itself, but it often rhymes".

So what can we expect in 2021? For the ASEG, my hope is that state branches embrace hybrid technical sessions. Longer-term Members will remember when the Federal Executive was state bound. When conference telephony became an option the Executive became national, as befits the Australian Society of Exploration Geophysicists. I can personally attest to the remarkable change in communication for the better as video conferences replaced telephony in my own time on the Federal Executive.

Video presentations are an excellent means to reach a much wider audience than can ever be hoped for at monthly technical nights, and I would encourage presenters to think in longer time frames. True, the time taken preparing a talk can be significant and it can be daunting to present material. However, recording such talks provides massive leverage of that effort to an audience that would otherwise not have the opportunity to see the work. Figure 1 updates a similar figure in my *President's Piece* from *PV* 208. A few points are worthy of comment. Firstly, the number of views is presented on a logarithmic scale to cater for the large range. Secondly, the number of views increases over time. Because YouTube can be searched, and indeed recommends videos, the likelihood that a presentation will be recommended or found, and therefore viewed, increases over time. Typically, technical night presentations are not indexed and therefore have Mayfly-like longevity. Finally, while there is a wide range of variation, webinars on the ASEG's YouTube channel can generally expect around 100 views. This would generally exceed numbers present at a typical technical night, and also those present at a conference session.

It is natural to ask what makes a successful webinar. One criterion for success would be combined total attendance, the proportion of ASEG Members attending that webinar and YouTube viewing. It is not a perfect metric since it is skewed towards the long term. Nevertheless, by this criterion two webinars stand out. **Peter Betts**' webinar from 26 May and **Indrajit Roy**'s webinar from 15 July score highly using this criterion. Both had large numbers of attendees, and a large percentage of those attendees were ASEG Members. Both webinars also had a large number of views on our YouTube channel.

It is also worthwhile mentioning webinars by **Rich Bartlett**, **Anshuman Pradan** and **Alberto Ardid Segura**. All three presenters have clearly used the ASEG's YouTube channel to advertise their work amongst their various networks.

I would therefore encourage all state branches towards hybrid technical presentations in 2021 and beyond. Publicity for your branch and its sponsors, the presenter and their work are compelling arguments. For intending presenters, I encourage you to ask that your presentation be recorded as a webinar for wider viewing.

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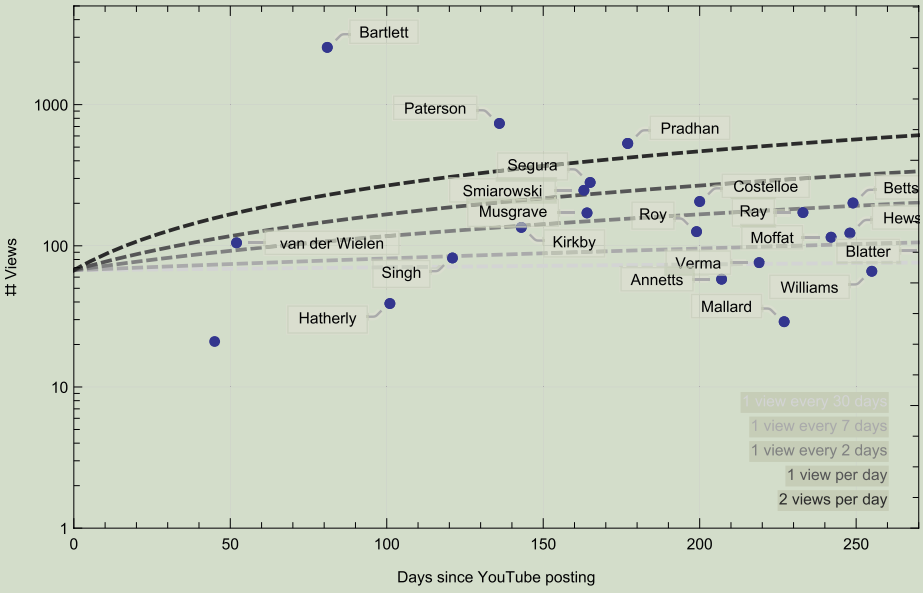

Figure 1. *Webinar views on the ASEG's YouTube channel over time.*

Executive brief

The Federal Executive of the ASEG is the governing body of the ASEG. It meets once a month, via teleconference, to deal with the administration of the Society. The following brief reports on the monthly meetings that were held in November and December 2020. If you wish to know more about any ASEG matters, please contact Leslie at fedsec@aseg.org.au.

Finances

The Society's financial position at the end of November:

Year to date income: $219 781

Year to date expenditure: $245 030

Net assets: $1 050 336

Due to the lack of branch meetings during the COVID-19 restrictions, the total expenditure is well down on the budgeted amount.

Membership

Please remember to renew your membership for 2021. If you have not yet renewed your membership, you should receive a reminder email soon with all the details on how you can renew. During 2021, the FedEx will continue to review membership options, including some changes to the retired membership category, to give everyone the best opportunity to continue their membership. Five-year membership options are available to Active/Associate and Retired Members. Early and mid-career Members are also encouraged to join the ASEG Young Professionals Network at www.aseg.or.au/about-aseg/aseg-youngprofessionals.

As of 12 January 2021, the Society had 579 financial Members, compared to 588 at this time in 2020, after we finished 2020 with 895 members. The ASEG finished the year with seven Corporate Members, including three Corporate Plus Members, of which five have so far continued to support us in 2021. A huge thanks to all our Corporate Members for your continued support into 2021. Don't forget to have a look for our Corporate Members on the contents page of *Preview,* and to support them as much as you can. Our state branches also have additional local sponsors, and these are shown at all branch meetings and at the beginning of all webinars.

Survey

In the coming months you will receive a short membership survey. Your feedback is important to the FedEx so we can continue to provide our membership with the best outcomes. We appreciate you taking some time to complete the survey.

Website

Ian James was very busy in the later stages of 2020 and has uploaded an (almost) complete library of all back editions of *Preview*. Have a browse and see how far the Society has come over the 35 years of printing *Preview*. If you come across a back issue of *Preview* in your archive that is not present on the website, Ian would be very grateful for a copy. Ian's details can be found in the table of ASEG officeholders on the inside front cover of *Preview*.

Social media

Stay up-to-date with all the happenings of your Society on social media. You can connect to us on LinkedIn, Facebook and Twitter for all the latest news and events.

Online events

COVID restrictions are likely to continue in many states into 2021, so the ASEG will continue with the webinar series with some interesting talks as well as face-to-face meetings where possible. The webinars are coordinated and run at both state and federal level. Sessions are all recorded and available for viewing at the ASEG website or on our YouTube Channel. Keep a look out for notifications from your state branches to see what is coming and get out there and reconnect with your colleagues.

If there is anything you wish to know more about, please contact Leslie at fedsec@aseg.org.au.

Leslie Atkinson
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Welcome to new Members

The ASEG extends a warm welcome to 11 new Members approved by the Federal Executive at its December and January meetings (see Table).

First name	Last name	Organisation	State	Country	Membership type
Yi	Hi	University of Adelaide	SA	Australia	Student
Ron	Gower	Wireline Services	WA	Australia	Active
Julien	Lepine	Newexco	WA	Australia	Associate
Gerrit	Olivier	Institute of Mine Seismology	TAS	Australia	Active
Evren	Pakyuz-Charrier	UWA & Geocure 3D	VIC	Australia	Active
Mitchell	Pearce	Newexco	WA	Australia	Active
Ryan	Spaulding		TAS	Australia	Associate
Cyrille Donald Njiteu	Tchoukeu	University of Douala	Douala	Cameroon	Student
Thomas	Tsiboah	Newmont	CO	United States	Active
Jasi	Watson	Anglo American	QLD	Australia	Active
Ismail	Yavuz	Resource Potentials	WA	Australia	Active

Notice of Annual General Meeting (AGM)

The 2021 AGM of the Australian Society of Exploration Geophysicists (ASEG) will be held on April 6, 2021 virtually through Zoom, at 17:30 ACST. Details will be supplied via email and the ASEG Newsletter.

The business of the Annual General Meeting will be:

- To confirm the minutes of the last preceding general meeting;
- To receive from the Federal Executive reports on the activities of the Society during the last preceding financial year;
- To receive and consider the financial accounts and audit reports that are required to be submitted to Members pursuant to the Constitution and to law;
- To consider and if agreed approve any changes to the ASEG Constitution;
- To report the ballot results for the election of the new office holders for the Federal Executive;
- To confirm the appointment of auditors for 2020.

The AGM will be proceeded by a scientific presentation with a speaker yet to be determined.

Invitation for candidates for the Federal Executive

Members of the Federal Executive serve in an honorary capacity. They are all volunteers and ASEG Members are encouraged to consider volunteering for a position on the Executive or on one of its committees. Current members are listed in *Preview*; please contact one of them if you wish to know more about volunteering for your Society. Self-nominations are encouraged.

In accordance with Article 8.2 of the ASEG Constitution ' … The elected members of the Federal Executive are designated as Directors of the Society for the purposes of the [Corporations] Act.'

The Federal Executive comprises up to 12 members, and includes the following four elected members:-

(i) a President
(ii) a President Elect
(iii) a Secretary, and
(iv) a Treasurer

These officers are elected annually by a general ballot of Members. Dr Kate Robertson was elected as President-Elect in 2020 and as such will stand for the position of President.

The following offices are also recognised:

(i) Vice President,
(ii) the Immediate Past President (unless otherwise a member of the Federal Executive),
(iii) the Chair of the Publications Committee,
(iv) the Chair of the Membership Committee,
(v) the Chair of the State Branch Committees, and
(vi) up to three others to be determined by the Federal Executive.

These officers are appointed by the Federal Executive from the volunteers wishing to serve the Society. Nominations for all positions (except Past President) are very welcome. Please forward the name of the nominated candidate and the position nominating for, along with the names of two Members who are eligible to vote (as Proposers), to the Secretary:

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Nominations must be received via post, fax or email no later than COB Tuesday 9 March 2021. Positions for which there are multiple nominations will then be determined by ballot of Members and the results declared at the Annual General Meeting.

Proxy forms and further details of the meeting will be sent to Members prior to the meeting by email, and made available to Members on the Society's website.

Free subscription to *Preview* online

Non-members of the ASEG can now subscribe to *Preview* online via the ASEG website. Subscription is free. Just go to https://www.aseg.org.au/publications/PVCurrent to sign up. You will receive an email alert as soon a new issue of *Preview* becomes available. Stay informed and keep up-to-date by subscribing now!!

NB: ASEG Members don't need to subscribe as they automatically receive an email alert whenever a new issue of Preview *is published.*

ASEG Young Professionals Network: Branch and AEGC 2021 updates

Western Australian Branch (Carolina Pimental, Todd Mojesky and Partha Pratim Mandal)

The Industry Mentoring Launch Night was held in Perth on November 16, 2020. A great night was had by all the participants where a good number of Mentors and Mentees met each other for the first time. Helping get things started was emotional intelligence expert Amy Jacobson, who taught us a few things about ourselves.

The Mentoring Programme was organized by the steering committee members and it is formed by eight different professional societies: Society for Underwater Technology (SUT) Perth Branch, Subsea Energy Australia, Petroleum Club WA, Australian Society of Exploration Geophysicists (ASEG), Wise Professional Network, SPE Western Australia (Society of Petroleum Engineers WA Section), PESA Petroleum Exploration Society of Australia and Engineers Australia.

The evening was a great opportunity of networking; reconnecting with industry colleagues and making new connections. Invaluable assets for a meaningful career, which is a huge part of what this programme is about.

The event was also full of information and insight, and excitingly opened a huge number of questions and new areas for our mentors and mentees to explore.

Stay tuned for regular updates on the programme, there will be some great stories to tell. More workshops are planned for 2021 to help grow the mentoring relationship between the participants.

Amy Jacobson presenting to participants in the WA Branch Industry Mentoring Programme

Participants in the WA Branch Industry Mentoring Programme

Queensland Branch (Janelle Simpson)

The Queensland cross-industry mentoring programme was launched virtually on November 3, 2020. The programme brought together mentors and mentees from across five different societies, spanning geology, geophysics and engineering professions. At the launch event attendees were treated to insights into what mentoring can offer from a mentors and mentees perspective, offered by Marina Costelloe and Rachel Kieft respectively. The evening was rounded out with a lively discussion of different ideas and perspectives on mentoring.

The Queensland cross industry mentoring programme builds on the success of the 2019 ASEG-PESA mentoring programme. The addition of the Society of Petroleum Engineers (SPE) Queensland Branch, Queensland Petroleum & Exploration Association (QUPEX) and Formation Evaluation Society of Queensland (FESQ), allows the

programme to reach a broader section of the resources industry. Participants of the programme will be involved in more events throughout 2021, fostering the mentoring relationships and networking across the cohort.

AEGC 2021 (Kat Gioseffi and Nicholas Josephs)

The AEGC 2021 is fast approaching, and we have a sneak peek at the Early Career and Student focused events for the upcoming conference, to be held in Brisbane this September:

Thursday 16 September 2021

Meet and Greet at the 'Brisbane Sign' by the river in Southbank:

- An informal get-together prior to the conference Welcome Reception as a bit of an ice breaker and a chance to meet fellow students and young professionals.

Fortescue Metals Group (FMG) Early Career Networking Event:

- A fun night of networking with students, fellow young professionals and industry with some competitions, lucky door prizes and a bar tab thrown in! To be held at a nearby venue after the Welcome reception.

Friday 17 September 2021

High School Student Day:

- A structured full day programme of speakers, demonstrations, and activities for Year 10-12 students.

Saturday 18th September 2021

Tertiary Student Afternoon Industry panel & Student and Early Career presentation competition:

- An afternoon session with an Industry Q&A Panel followed by a fast-paced 3-minute presentation competition – open to all students and young professionals. More details to come!!

Student Bursaries

The QLD branch of ASEG usually offers bursaries to cover travel for students or new graduates to large ASEG conferences. As we are hosting, the bursaries will be offered first and foremost to regional students this year. If you are or know of an interested party please contact qldsecretary@aseg.org.au or nick@energeo.com.au.

Jarrod Dunne
ASEG Young Professionals Network Federal Chair
ypadmin@aseg.org.au.

ASEG Honours and Awards: Call for 2021 nominations now open

An important role of the ASEG is to acknowledge the outstanding contributions of its individual Members both to the profession of geophysics and to the ASEG. The Society has a number of different Honours and Awards across a range of categories. Nominations are now open for the next round of Awards, scheduled to be presented in conjunction with AEGC 2021, 15 - 20 September 2021, Brisbane, Australia.

All ASEG Members as well as State and Federal executives are invited to nominate those they consider deserving of these awards. A list of the various available awards is set out below.

These awards carry considerable prestige within the Society and the geoscience community and therefore require some documentation to support the nomination. Please visit https://www.aseg.org.au/about-aseg/honours-awards or contact the Committee Chair if you require further guidelines on what is required.

ASEG Gold Medal

For exceptional and highly significant distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community. The nominee must be a Member of the ASEG.

Honorary Membership

For distinguished contributions by a Member to the profession of exploration geophysics and to the ASEG over many years. Requires at least 20 years as a Member of the ASEG.

Grahame Sands Award

For innovation in applied geophysics through a significant practical development of benefit to Australian exploration geophysics in the field of instrumentation, data acquisition, interpretation or theory. The nominee does not need to be a Member of the ASEG.

Lindsay Ingall Memorial Award

For the promotion of geophysics to the wider community. This award is intended for an Australian resident or former resident for the promotion of geophysics (including but not necessarily limited to applications, technologies or education), within the non-geophysical community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The nominee does not need to be a geophysicist nor a Member of the ASEG.

Early Achievement Award

For significant contributions to the profession by a Member under 36 years of age, by way of publications in *Exploration Geophysics* or similar reputable journals, or by overall contributions to geophysics, ASEG Branch activities, committees, or events. The nominee must be a Member of the ASEG and have graduated for at least 3 years.

ASEG Service Awards

For distinguished service by a Member to the ASEG, through involvement in and contribution to State Branch committees, Federal Committees, Publications, or Conferences over many years. The nominee will have been a Member of the ASEG for a sustained period of time. All nominations will be considered for the award of an ASEG Service Certificate. Where the nomination details outstanding contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years, consideration will be given to the award of the ASEG Service Medal to the nominee. Honorary Members are not eligible for nomination.

Nomination procedure

Any Member of the Society may submit nominations. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (e.g. GSA, AusIMM, AIG, IAH, ASEG or similar).

Nominations must be specific to a particular award and all aspects of the defined criteria should be addressed. To view the criteria for each award and the information required for a nomination, nominators are advised to access and view the nomination guidelines and *pro forma* nomination forms at: https://www.aseg.org.au/about-aseg/honours-awards

Pro forma nomination forms are also available by contacting the Committee Chair. Nominations including digital copies of all relevant supporting documentation are to be sent electronically to the Chair, ASEG Honours and Awards Committee via email: awards@aseg.org.au

ASEG Branch news

Queensland

On 15 December 2020, the ASEG QLD branch had a combined Christmas drinks and technical night at the XXXX Brewery.

Dr **Phil Schmidt** of Magnetic Earth (formerly of the CSIRO) visited Brisbane and gave a talk. Phil's talk; "The role of geophysics in mineral exploration today", elaborated on the content of a book soon to be released by CSIRO that will include published research reports from the past 40 years, some of which have been embargoed since they were written (available at https://confluence.csiro.au/display/cmfr/Home).

Phil elaborated on the role of geophysics in exploration and in particular on Queensland prospective areas outlining excerpts from these CSIRO reports. After the introduction of the book, Phil examined two areas where geophysics has taken a leading role and led to a breakthrough.

Firstly, Phil briefly summarised a few papers that suggest there are a range of mineral deposit types that are spatially associated with the margins of long-lived relatively cold, buoyant Precambrian cratons or lithosphere roots, and opined that that economic geology research should be broader and consider the geodynamic setting instead of the common mineral system scale.

Secondly, Phil explained how seismology and palaeo-magnetism has assisted in pinpointing the source of large igneous provinces and kimberlite fields, and how these studies have correlated large low shear-wave velocity provinces on the core-mantle boundary beneath Africa and the Pacific with large igneous provinces and kimberlite fields since Pangea formed.

The talk and subjects were supported by interesting and engaging graphics and was well received by the audience.

Subject to renewed restrictions in the greater Brisbane area, ASEG Queensland Technical Meetings will commence in 2021 on Tuesday 9 February with a talk by **Tim Pippett** of Alpha Geoscience on "The world of environmental geophysics (geophysics in the near-surface)"**.**

We'll look to hold our AGM in March, and welcome volunteers for committee positions or to give technical talks in 2021.

The Queensland committee would like wish everyone a happy New Year and are hoping for a productive and successful 2021.

James Alderman
qldsecretary@aseg.org.au

South Australia & Northern Territory

The SA-NT Branch were delighted to finish last year with a joint Christmas Party and Technical Evening with a talk by **Matthew Zengerer** from Gondwana Geoscience entitled "Application of Machine Learning to domaining of potential field data and subsurface geology predictions". The event was held on the evening of Thursday, 17 December at the Union Hotel. It was great having members from the NT joining us by Zoom so that they could watch Matthew's fascinating talk and join in with the festivities.

I would like to take this opportunity to thank our local sponsors of 2020: Beach Energy, Oz Minerals, Vintage Energy, Heathgate and Minotaur Exploration. We would also like to thank Terrex Seismic who sponsored our annual Melbourne Cup Luncheon.

The SA/NT branch looks forward to seeing more of everyone in 2021 as we look to returning to our usual busy calendar within the new normal.

Ben Kay
sa-ntpresident@aseg.org.au

Tasmania

ASEG Tasmania branch members are encouraged to register for the Australian Earth Sciences Convention (9-12 February 2021), which is being hosted by the Tasmania branch of the Geological Society of Australia, almost entirely online (several field trips and social events are proceeding locally). The program contains many presentations of geophysical and/or Tasmanian interest. As most presentations will be pre-recorded, registered delegates will be able to review them at leisure after the nominal conference dates, in addition to live streaming plenary session speakers and Q&A.

Meeting notices, details about venues and relevant contact details can also be found on the Tasmanian Branch page on the ASEG website. As always, we encourage members to keep an eye on the seminar/webinar programme at the University of Tasmania / CODES, which routinely includes presentations of a geophysical and computational nature as well as on a broad range of earth sciences topics.

Mark Duffett
taspresident@aseg.org.au

Matthew Zengerer presenting to the SA-NT branch in person and via Zoom.

Victoria

I know I have said this before, but I will bleeding say it again – why, oh why does our spirited Editor enforce such a callous deadline for submission of branch news to *Preview* so early in January every year??? I am not very organised at this time of the year, or even coherent for that matter, having just awakened from two-weeks of self-indulgent wickedness during the festive slumber. If only writing these contributions was a paying gig, which by the way, is not a bad idea at all. Hmmm…perhaps I could broach the subject in a Letter to our Editor.

With most travel restrictions imposed during the pandemic now lifted, I managed to escape to Cape Paterson along the picturesque Bunurong coastline in southeast Victoria. In fact, I visited Eagles Nest – no, not the Third Reich-era house at Kehlstein alpine peak in Germany – but the site of the very first recorded discovery of a dinosaur bone in Australia in 1903 by geologist William Ferguson. Apparently he was out and about tracing coal seams, which typically weave through the region, but instead stumbled upon a dinosaur claw. Wowsers! This rugged Jurassic coastline is visually spectacular and is a palaeontologist's paradise. Just ask environmentalist/conservationist/palaeontologist and explorer Tim Flannery, recipient of the Australian of the Year Award in 2007, who was among a small party in 1978 that uncovered many, many more fossils at the site. Can anyone say 'Qantassaurus'?

Anyhow, I look forward to seeing what 2021 may bring to members of our Victorian branch. Maybe an effective COVID vaccine? Maybe the recommencement of our technical meeting nights? Maybe. Just, maybe.

Thong Huynh
vicpresident@aseg.org.au

Western Australia

Well, we've all punched through that annoying year of 2020, and are looking forward to a much better 2021 - with some crossed fingers. That being said, we did manage to have a pretty darn decent December 2020 in WA. We hosted one last (and fascinating) webinar on December 16, a talk by **Ain Nadrah Noor Sazali** from Iraya Energies that actually covered our entire Bonaparte Basin: "Efficient exploration in the Bonaparte Basin Using Unstructured Data Analytics with ElasticDocs". Iraya has a mature machine learning tool to cut through all of the huge piles of random data floating around on project areas and pull out the nuggets - pretty cool.

Eagles Nest, Cape Paterson, Victoria.

The WA branch 50th anniversary/ AGM/ Christmas celebrations.

Meanwhile, we were feverishly working on a couple of plans to truly celebrate ASEG's 50th Anniversary (albeit, 2020). The first step was to design and purchase anniversary ASEG hats for our local members, and then present them to our members at an AGM/50th Anniversary/Christmas party at a special venue on December 17. Due to the flogging efforts of **Darren Hunt** (our new treasurer), the hat suppliers did cough them up - just on the afternoon of our event! The party was located in a brewpub (Bright Tank Brewing Company), and was darn well attended. This was actually WA ASEG's first face-to-face since the inception of COVID, and so we were all looking forward to some good food, crafted beers, and mixing (safely) with old/new friends. A very brief speech from me, and we verbally voted in the committee. We also gave a big set of thanks to **Mathew Cooper**, our outgoing treasurer - with a few good bottles of wine for him to take home. The party continued on till late…

For 2021, the WA branch will be shooting for a return of face-to-face Tech Nights (second Wednesday of the month, from vague memories), with the first planned to be a Student Night. This all assumes that we continue to have COVID under control, naturally. In the meantime, the webinars have proven to be a monster success, so we will also continue with them. We've also got more of our hats that weren't yet handed out to our local Members, so for that, or other ideas and suggestions, please feel free to contact our secretary or myself.

Have a great New Year…

Todd Mojesky
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Australian Capital Territory

Geophysicists around the world were shocked and saddened by the death on New Year's Day of one of the most prominent members of the ACT branch; **Richard Lane**. Richard's funeral was held on January 12 and many ASEG Members attended in person or virtually, as the funeral was live streamed. **Marina Costelloe**, ACT Branch President and a long-term friend and colleague of Richard's gave a moving address, and **David McInnes** read a tribute from **Bob Smith**, also a long-term friend and colleague. David embroidered Bob's tribute with his own very fond memories of Richard.

Mike Barlow
actsecretary@aseg.org.au

The WA branch's 50th anniversary celebrations.

New South Wales

Happy New Year ASEG Members! By the time you read this, we should be all settled into 2021 and fingers crossed it's shaping up to be better than the year that was 2020.

In November, we concluded the 2020 NSW webinar series with the annual student evening. We had two post-graduate students present their research:

Kelly Vaughn-Taylor (Macquarie Uni) "Melting conditions beneath the Newer Volcanics Province from probabilistic inversions of lava compositions and geophysical data"

Tom Zhao (UNSW) "Machine learning of EM and gamma ray data for the lime application on the farmland".

The presentations were interesting and informative, enjoyed by the attendees and followed by discussion.

For a short while, it looked like things were getting back to "normal", we even managed to host a physical (but socially-distant) event – the annual trivia night. Despite the usual busy nature of December, many of our regular trivia attendees made an appearance, in addition to a few new faces. Questions ranged from initial name of the COVID-19 virus to identifying Evans Crown Granite from a photograph. There were many laughs, a little light-hearted disagreement and some friendly competition; but, in the end there could only be one winner - the blue team. A big thank you to the trivia team, **Mike Smith** and **Josh Valencic**, for helping organise and host the event. Fortunately, the trivia night was held right before the clusters emerged and saw some parts of Sydney go into lock-down. Whether the 2021 presentations are online or in-person, we look forward to seeing more of you. Stay safe everyone!

Mark Lackie
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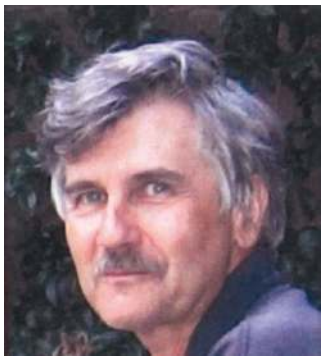
Stephanie Kovach
nswsecretary@aseg.org.au

ASEG national calendar

Date	Branch	Event	Presenter	Time	Venue
ASEG Branch face-to-face meetings have resumed in SA, WA and Tasmania. All other State Branch meetings are on hold till further notice. Most branches are still hosting webinars. Registration is open to Members and non-members alike, and corporate partners and sponsors of state branches are acknowledged before each session. Recorded webinars are uploaded to the ASEG's website (https://www.aseg.org.au/aseg-videos), as well as to the ASEG's YouTube channel (https://bit.ly/2ZNgIaZ). Please monitor the Events page on the ASEG website for information about upcoming webinars and other on-line events					
09 Feb	QLD	Technical night	Tim Pippett	17:30	XXXX Brewery (Alehouse), Black St, Milton, Brisbane
10 Feb	WA	Technical night	TBA	17:30	TBA
16 Feb	National	Webinar	Kate Selway	13:00	https://us02web.zoom.us/webinar/register/WN_OPdMzdnaQbapkiVh7a4ViQ
Mar	QLD	AGM	TBA	17:30	XXXX Brewery (Alehouse), Black St, Milton, Brisbane

Vale: Peter Anthony Hopgood (1949-2020)



Peter Hopgood

It is with sadness that I report on the death of our friend and colleague Dr Peter Hopgood on 01 November 2020 in Canberra, Australia.

Peter was an ionospheric physicist by training, and completed his doctorate research on atmospheric air-glow at Melbourne's La Trobe University in 1976. At that time La Trobe was a newly established university, and Peter was among the inaugural intake of students. After completing his university studies Peter re-located to Canberra to undertake atmospheric studies with Dr Kurt Lambeck at the Research School of Earth Science, Australian National University. He then worked on modelling the Earth's response to electromagnetic signals in the Metalliferous and Airborne section at the Bureau of Mineral Resources, Geology and Geophysics. In 1982 he transferred to BMR's geomagnetism program where he worked until retirement in 2008.

During his career Peter managed the Canberra geomagnetic observatory, undertook countless instrument and compass calibrations and oversaw many upgrades and improvements throughout the Australian geomagnetic observatory network. He led the geomagnetism program until 2005 and was integral in the establishment of the geomagnetic observatories at Charters Towers (CTA), Learmonth (LRM) and Gingin (GNG). For more than 20 years his data processing algorithms and software were at the heart of Australia's geomagnetic processing and data dissemination system. Another of Peter's major contributions was the task of compiling and distributing the annual Australian Geomagnetism Reports from 1993 to 2005, and its monthly predecessor from 1982. Peter authored a variety of scientific papers, encyclopaedia entries, newspaper articles, radio and TV interviews and contributed to the International Association of Geomagnetism and Aeronomy project automating K-index scaling to monitor planetary geomagnetic activity. His work on a real-time magnetic total intensity variability map of the Australian continent remains an invaluable tool for magnetic surveying and research.

Peter was also a dedicated cyclist and commuted by bicycle to the office almost every day throughout his entire career, and continued his love of cycling into retirement.

Peter provided quiet, confident scientific leadership and mentored a generation of Australian geomagnetic observatory scientists. Peter passed away after a period of illness and is survived by his wife Elizabeth, children Paul, Christina and grand-daughter Lydia. He will be much missed and remembered by everyone who worked with him.

Andrew Lewis
Geoscience Australia
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Vale: Leslie John Starkey (1934-2020)

Les Starkey

It is with sadness and pause that we report a long standing ASEG Member and truly great mentor, Leslie "Les" Starkey, passed away on 3 August this year. Les is survived by his wife Norma and children Robert and Julie.

Les spent most of his career as a consulting geophysicist working in oil and mineral exploration. He obtained a BSc major in physics and minor in mathematics from University of Queensland in 1955, and an MSc in geophysics from UWA in 1977. Les helped carry out a large number of commercial geophysical surveys in Australia starting in the mid-late 1950s, served as a lecturer in geophysics at the University of Melbourne in the early 1960s, was involved in airborne and ground geophysical surveying and data processing in Australia with McPhar in the mid-1960s, and in Canada in the late 1960s, and carried on in Australia and PNG in the 1970s to 1990s working for Mobil Energy Minerals, and then with many of the same team at CEGB, as well as Great Central Mines. He lectured in geophysics at Curtin University (WAIT) on an off during this time. He was always a keen supporter of the Curtin Department of Exploration Geophysics, and helped mentor many graduates during his association with the Department.

For both of us (KF at Mobil in the early '80s and JM at Great Central Mines in the early '90s), Les was a gentle mentor, always willing to openly share ideas, while listening to others' ideas and helping make them a reality; and this mentorship continued well after leaving those companies. He was an innovative thinker when it came to new ways of filtering potential field data, especially trying to obtain depth information from frequency content in datasets, which became superseded/forgotten when inversion modelling took over.

Les also had a keen interest in applying geophysics for detecting offshore and buried coastal shipwrecks in WA, and served on the board of mineral exploration companies, most recently Cashmere Iron. Although he wound back a little, he never really retired and was still involved in geophysical exploration up until the time of his death.

Les joined the ASEG in its second year in 1971, and was always quietly working on something interesting when one met him at local branch meetings. Les the "gentleman geophysicist" will be truly missed!

Jayson Meyers and Kim Frankcombe
jaysonm@respot.com.au
kim@exploregeo.com.au

Geoscience Australia: News

It was a very sad start to the year with the passing of Geoscience Australia's Richard Lane: world-acclaimed geophysicist, long-term member of the GA-family and a humble professional who mentored many of us on the principles through to the applications of EM and potential fields. James Johnson, CEO of Geoscience Australia, eloquently summed up Richard's contribution and character:

"It is with great sadness that I share the news of the passing of our colleague and friend Richard Lane.

Richard joined Geoscience Australia nearly 20 years ago and, due to his professional contribution, is now widely recognised throughout the global geophysical community for his keen intellect and insight into geophysical methods in minerals, energy groundwater and hazards. His role at Geoscience Australia allowed him to share his knowledge widely to improve the science of understanding the potential of Australia's resources wealth.

Richard first joined Geoscience Australia in 2001 following a distinguished career in industry and academia. His expertise and contributions were wide ranging, including innovations in the airborne electromagnetic technique, 3D inversion and modelling of magnetics and gravity, as well airborne gravity and gravity gradiometry. These fields are now areas of technical strength in Geoscience Australia, with much of this capability due to Richard's endeavours.

Richard was instrumental in the development of the Geomodeller 3D geological modelling package and in establishing a national rock properties database to inform regional modelling studies. He has organised numerous pertinent and timely geoscientific seminars as well as mentoring many younger scientists and graduates in the application of numerical methods for geoscientific problems.

Richard authored or co-authored numerous scientific publications, and was the recipient of many awards, the most prestigious being the Australian Society of Exploration Geophysicists Gold Medal in 2017 for "exceptional and highly significant distinguished contributions to the science and practice of geophysics by a member, resulting in wide recognition within the geoscientific community".

Richard made significant contributions to a number of high profile Cooperative Research Centres including CRC AMET where he led the development of the TEMPEST AEM system. Late last year Richard played a leading role in the development of the 6th edition of the National Gravity Grids, incorporating, for the first time, ground, airborne and satellite data. This represented the culmination of one of Richard's long held visions for integrating gravity data.

Richard was a patient, deep-thinking and outstanding scientist. He effortlessly juggled multiple domain specialties and was humble about his own achievements. Richard was incredibly generous with his time and knowledge. He would share his insights, knowledge and wisdom openly through mentoring and workshops. Richard will be deeply missed by us all.

Peace and comfort be with you, Richard".

Richard Lane

While appearing in last *Preview*, it is somewhat fitting to reproduce Richard's most recent accomplishment; namely the development of a technically-robust merge of airborne, marine and satellite gravity covering Australia through to its offshore continental margins. Packaged under the 2020 National Gravity Compilation (see below), the final product: a de-trended global isostatic residual map, was formally unveiled by Richard on the 16 December (Figure 1).

2020 National Gravity Compilation

Geoscience Australia was pleased to release the 2019 national gravity compilation on 7 October 2020. The release represented the first time ground gravity, airborne gravity/gravity gradiometry, satellite and marine gravity observations were combined to produce a series of national gravity grids covering an area more than twice the size of the country. GA's electronic catalogue provides a full suite of these grids, including processing notes and intermediate to final products (see http://pid.geoscience.gov.au/dataset/ga/133023).

The catalogue summary explains:

"The 2019 Australian National Gravity Grids are two sets of grids (the "A" and "B" Series) covering the continent of Australia and surrounding region (108 to 164 degrees East Longitude, 8 - 48 degrees South Latitude). Each of the two series consist of five grids - three gravity grids and two supplementary grids defining the observation surface of the gravity grids. The gravity grids provide values of Free Air Anomaly (FAA), Complete Bouguer Anomaly (CBA), and De-trended Global Isostatic Residual (DGIR). The first of the supplementary grids defines the height of the observation surface with respect to the geoid vertical datum, whilst the second supplementary grid defines the height of the observation surface with respect to an ellipsoid vertical datum (i.e., the GDA94 datum which employs the GRS80 ellipsoid). The A Series grids were produced from a combination of ground gravity data for continental Australia and data from a global gravity grid for the surrounding region. The observation surface was the ground or ocean surface. The B Series grids used the same data as the A Series grids with the addition of data from twelve airborne gravity surveys and two airborne gravity gradiometer surveys. The observation surface for the B Series grids was a smooth drape surface with a minimum surface clearance of 250 m." (Lane *et al* 2020).

Reference

Lane, R. J. L., Wynne, P. E., Poudjom Djomani, Y. H., Stratford, W. R., Barretto, J. A. and Caratori Tontini, F. 2020. 2019 Australian national gravity grids explanatory notes. Record 2020/22. Geoscience Australia, Canberra.

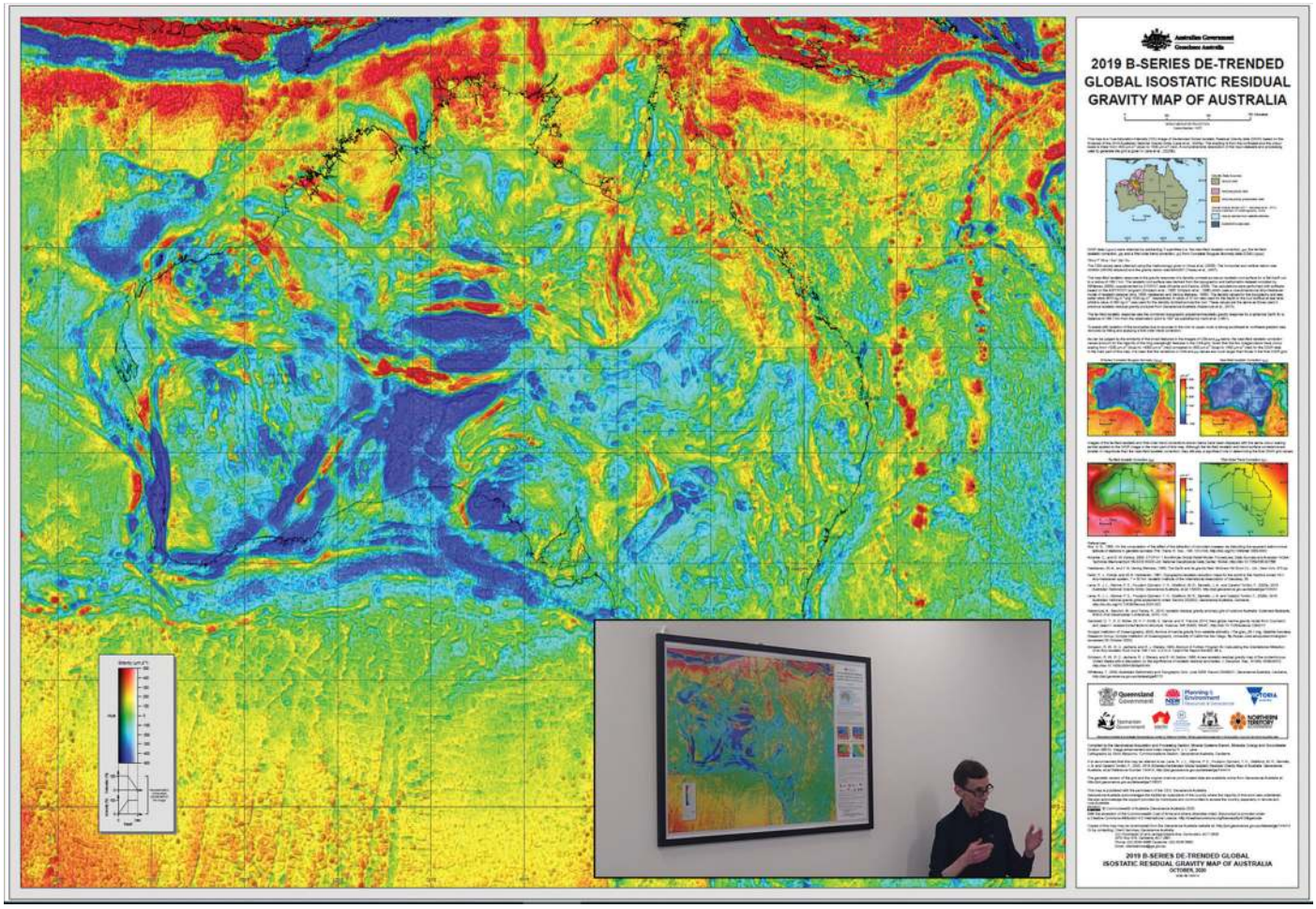

Figure 1. *B-series de-trended global isotatic residual gravity map of Australia, 2019. Source: Lane et al, 2020. Inset – Richard enthusiastically explaining the intricacies of the gravity merge to his GA colleagues, 16 December 2020.*

Geophysical surveys

With our key collaborative State Agency partners of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania, GA continues to acquire and process high quality pre-competitive geophysical products to build Australia's future. A summary of programs and survey locations can be found in Figure 2 and the tables in the following section.

Mike Barlow
Geoscience Australia
Mike.Barlow@ga.gov.au

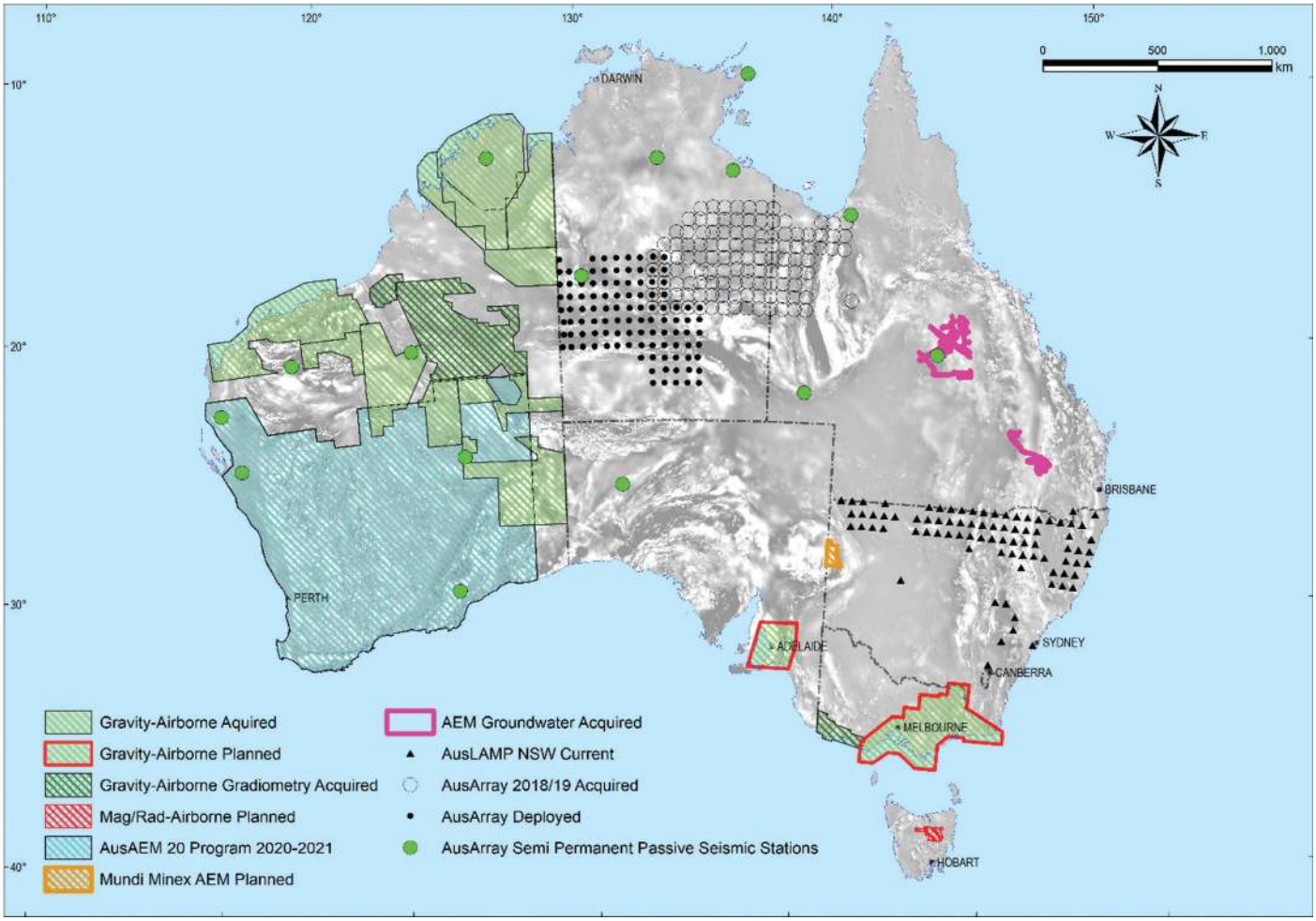

Figure 2. *2019 -2021 geophysical surveys – in progress, planned or still for release by Geoscience Australia in collaboration with State and Territory agencies*

Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 8 January 2021).

Further information about these surveys is available from Mike Barlow Mike.Barlow@ga.gov.au (02) 6249 9275 or Marina Costelloe Marina.Costelloe@ga.gov.au (02) 6249 9347.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Line spacing Terrain clearance Line direction	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Tasmanian Tiers	MRT	GA	MAGSPEC	Mar 2021	Up to an estimated 25 000	200 m 60 m N–S or E–W	4300	Before end of 2021	TBA	See Figure 1 in previous section (GA News)	TBA
Cobar	GSNSW	GA	TBA	~ Jun 2021	46 000	200 m	9200	Before end of 2021	TBA	See Figure 1 in previous section (GA News)	TBA

TBA, to be advised.

Table 2. Ground and airborne gravity surveys

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Melbourne, Eastern Victoria, South Australia	AusScope	GA	TBA	~Dec 2020	137 000	1–5 km	146 000	TBA	TBA	See Figure 1 in previous section (GA news)	TBA
Kidson Sub-basin	GSWA	GA	CGG Aviation	14 Jul 2017	72 933	2500 m	155 000	3 May 2018	15 Oct 2018	The survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	Set for release before Jun 2021
Little Sandy Desert W and E Blocks	GSWA	GA	Sander Geophysics	W Block: 27 Apr 2018 E Block: 18 Jul 2018	52 090	2500 m	129 400	W Block: 3 Jun 2018 E Block: 2 Sep 2018	Received by Jul 2019	195: Aug 2018 p. 17	Set for release before Jun 2021
Kimberley Basin	GSWA	GA	Sander Geophysics	4 Jun 2018	61 960	2500 m	153 400	15 Jul 2018	Received by Jul 2019	195: Aug 2018 p. 17	Set for release before Jun 2021
Warburton-Great Victoria Desert	GSWA	GA	Sander Geophysics	Warb: 14 Jul 2018 GVD: 27 Jul 2018	62 500	2500 m	153 300	Warb: 31 Jul 2018 GVD: 3 Oct 2018	Received by Jul 2019	195: Aug 2018 p. 17	Set for release before Jun 2021
Pilbara	GSWA	GA	Sander Geophysics	23 Apr 2019	69 019	2500 m	170 041	18 Jun 2019	Final data received Aug 2019	See Figure 1 in previous section (GA News)	Set for release before Jun 2021
SE Lachlan	GSNSW/ GSV	GA	Atlas Geophysics	May 2019	303.5 km with 762 stations	3 regional traverses	Traverses	Jun 2019	Jul 2019	See Figure 1 in previous section (GA News)	Set for incorporation into National database by Dec 2020

TBA, to be advised

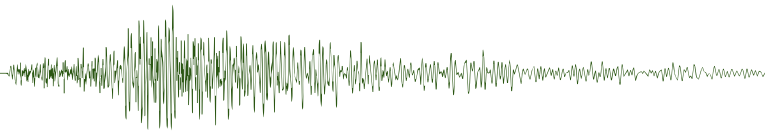

Table 3. Airborne electromagnetic surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Mundi	GSNSW	GA	NRG	Mar 2021	1900	2.5	~ 5000	May 2021	TBA	See Figure 1 in previous section (GA News)	TBA
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	2 Jul 2017	4627	Variable	57 366	23 Jul 2017	Nov 2017	188: Jun 2017 p. 21	TBA
AusAEM20	GSWA	GA	CGG & SkyTEM	Aug 2020	62 000	20 km	1 240 000	Dec 21	TBA	See Figure 1 in previous section (GA News)	TBA. Survey in production

TBA, to be advised

Table 4. Magnetotelluric (MT) surveys

Location	Client	State	Survey name	Total number of MT stations deployed	Spacing	Technique	Comments
Northern Australia	GA	Qld/NT	Exploring for the Future – AusLAMP	366 stations deployed in 2016–19	50 km	Long period MT	The survey covers areas of NT and Qld. Data to be released early 2021.
AusLAMP NSW	GSNSW/ GA	NSW	AusLAMP NSW	224 stations deployed in 2016-19	50 km	Long period MT	Covering the state of NSW. Acquisition ongoing. Phase 1 data release: http://pid.geoscience.gov.au/dataset/ga/132148.
Southeast Lachlan	GSV/GSNSW/ GA	Vic/ NSW	SE Lachlan	Deployment planned to commence early/mid-2021	~4 km	AMT and BBMT	~160 stations in the Southeast Lachlan. Acquisition delayed due to COVID-19 travel restrictions.
AusLAMP TAS	GA	TAS	King Island MT	4 stations completed	<20 km	Long period MT	Covering King Island. Acquisition completed.
Cloncurry	GSQ/GA	QLD	Cloncurry Extension	500 stations have been acquired	2 km	AMT and BBMT	Data acquisition complete.
Spencer Gulf	GA/GSSA/ UofA/ AuScope	SA	Offshore marine MT	12 stations completed	10 km	BBMT	This is a pilot project for marine MT survey https://www.auscope.org.au/news-features/auslamp-marine-01

TBA, to be advised

Table 5. Seismic reflection surveys

Location	Client	State	Survey name	Line km	Geophone interval	VP/SP interval	Record length	Technique	Comments
Eastern Goldfields	GSWA	WA	L132 1991 Eastern Goldfields Seismic	260	40 m	160 m	20 s	2D deep crustal seismic explosive reflection seismic	GSWA and GA signed an MoU to reprocess legacy explosive data acquired by GA's predecessor agency, the Bureau of Mineral Resources in 1991. GSWA contracted Velseis Processing Pty Ltd. to reprocess these data set using modern processing techniques, which were unavailable at the time of the original data acquisition and initial processing. GA will provide Quality Control and monitoring of the data reprocessing; and provide ad hoc advice for the project. The improved seismic data will complement other geoscience datasets in GSWA's Eastern Goldfields Reinterpretation Project, and GSWA's Accelerated Geoscience Program. The work is funded by the WA Government's Exploration Incentive Scheme.

(*Continued*)

Table 5. Seismic reflection surveys (*Continued*)

Location	Client	State	Survey name	Line km	Geophone interval	VP/SP interval	Record length	Technique	Comments
South East Lachlan	GSV/ GSNSW/ GA/ AuScope	Vic/NSW	SE Lachlan	629	10 m	40 m	20 s	2D deep crustal seismic reflection	The survey covers the Southeast Lachlan Orogen crossing the Victoria–New South Wales border. Data acquisition was completed in April 2018. Raw and processed seismic data are available from Geoscience Australia and state geological surveys: http://pid.geoscience.gov.au/dataset/ga/122684
Kidson	GA/ GSWA	WA	Kidson Sub-basin	872	20 m	40 m	20 s	2D deep crustal seismic reflection	The survey is within the Kidson sub-basin of the Canning Basin and extends across the Paterson Orogen and onto the eastern margin of the Pilbara Craton. Data acquisition was completed in Aug 2018. Raw and processed seismic data are available from Geoscience Australia and the Geological Survey of Western Australia: http://pid.geoscience.gov.au/dataset/ga/128284
Barkly/ Camooweal	GA/NTGS	NT	Barkly Sub-basin	813	10 m	30 m	20 s	2D deep crustal seismic reflection	The aim of the project was to acquire 2D land reflection seismic data to image basin and basement structure in the Barkly region in the Northern Territory. Data acquisition was completed in Nov 2019. Raw and processed seismic data are available via Geoscience Australia and the Northern Territory Geological Survey: http://pid.geoscience.gov.au/dataset/ga/132890

Table 6. Passive seismic surveys

Location	Client	State	Survey name	Total number of stations deployed	Spacing	Technique	Comments
Northern Australia	GA	Qld/NT	AusArray	About 135 broad-band seismic stations	50 km	Broad-band 1 year observations	The survey covers the area between Tanami, Tennant Creek, Uluru and the Western Australia border. The first public release of transportable array data is expected by the end 2020. See: http://www.ga.gov.au/eftf/minerals/nawa/ausarray Various applications of AusArray data are described in the following Exploring for the Future extended abstracts: http://pid.geoscience.gov.au/dataset/ga/135284 http://pid.geoscience.gov.au/dataset/ga/135130 http://pid.geoscience.gov.au/dataset/ga/135179 http://pid.geoscience.gov.au/dataset/ga/134501
Northern Australia	GA	Various	AusArray, semi-permanent	12 high-sensitivity broad-band seismic stations	~1000 km	Broad-band 4 years observations	Semi-permanent seismic stations provide a back-bone for movable deployments and complement the Australian National Seismological Network (ANSN) operated by GA, ensuring continuity of seismic data for lithospheric imaging and quality control. Associated data can be accessed through http://www.iris.edu" www.iris.edu

Geological Survey of South Australia: New geophysical data on SARIG

Geophysicists at the Geological Survey of South Australia are pressing forward in their task to release all mineral geophysical surveys in the public domain via the Jetstream tool available on SARIG (South Australia Resources Information Gateway). The Jetstream tool (a product created by Intrepid Geophysics) allows users to cookie-cut surveys to a desired size, reproject the ASCII or gridded data to a selection of datums and projections, and download their requested data via link sent by email.

This ever-growing collection of data is available for free download, and updates are reported quarterly on the Department for Energy and Minerals website. The website (link below) includes hyperlinks to the metadata and a direct link to download each dataset. These downloads include original data and reports as supplied to the SA Government, as well as processed data: Intrepid datasets, grids of the data, and shapefiles illustrating flightpaths and boundary shapefile. These packages come as-is, and cannot be cookie-cutted online as they can be via Jetstream. Figure 1 shows the geographical position of the surveys released in December 2020. This link https://www.energymining.sa.gov.au/minerals/exploration/exploration_data_releases#Geophysical will take you to a webpage which includes a table listing the surveys in the latest release, with hyperlinks to quickly access the data packages.

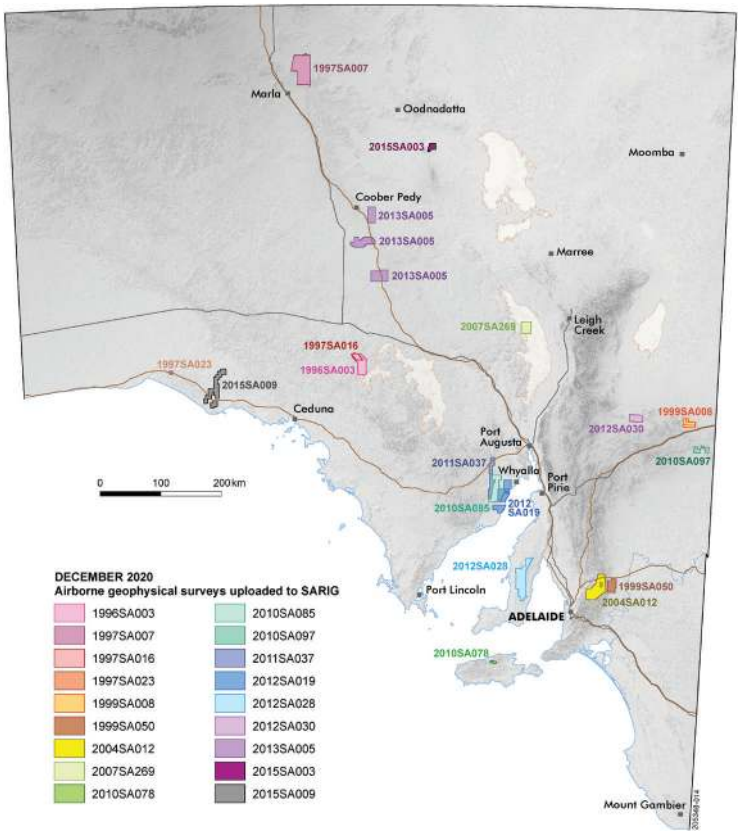

Figure 1. *Airborne geophysical surveys uploaded to SARIG in December 2020.*

As always, if you need any help accessing geophysical data in South Australia, please don't hesitate to contact customer resources at +61 8 8463 3000 or DEM.CustomerServices@sa.gov.au

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The ASEG in social media

Have you liked/followed/subscribed to our social media channels? We regularly share relevant geoscience articles, events, opportunities and lots more. Subscribe to our Youtube channel for recorded webinars and other content.

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Facebook: https://www.facebook.com/AustralianSocietyOfExplorationGeophysicists

LinkedIn company page: https://www.linkedin.com/company/australian-society-of-exploration-geophysicists/

Twitter: https://twitter.com/ASEG_news

YouTube: https://www.youtube.com/channel/UCNvsVEu1pVw_BdYOyi2avLg

Instagram: https://www.instagram.com/aseg_news/

Geological Survey of New South Wales: All geophysical data now available online

Since late 2018 the Geological Survey of New South Wales (GSNSW) has undertaken a major project to catalogue, quality-assure and release company geophysical survey data across the state. A key deliverable, the online search and discovery and direct download of airborne geophysical surveys via MinView, was announced in *Preview* last year (April 2020 edition). The quality assured surveys were then used as building-blocks for an updated and improved state-wide magnetic merge of New South Wales, which was announced in *Preview*'s August 2020 edition. The new merge was well received by industry geophysicists and the release was well-timed for explorers currently participating in the upsurge in mineral exploration in New South Wales.

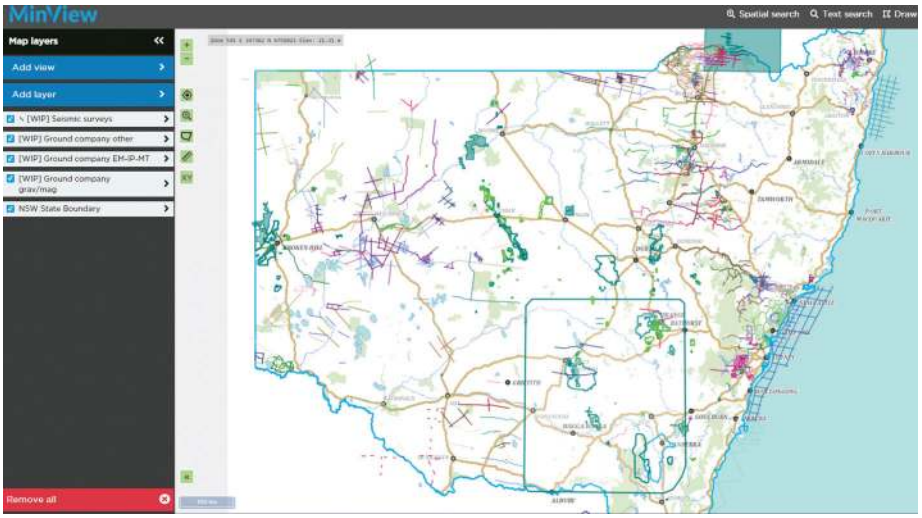

Figure 1. *MinView scene showing survey boundaries of ground geophysical surveys and line locations for seismic surveys.*

Following the release of the magnetics merge, GSNSW geophysicists continued the cataloguing and quality assurance of all available company geophysical survey data. The project was completed in December 2020. All ground geophysics, seismic and remote-sensed data can be now be searched and discovered through the GSNSW online data delivery portal, MinView. Around 450 ground geophysics surveys and over 220 seismic surveys were catalogued during this project, significantly expanding the previous databases. Ground survey types are mainly gravity and magnetics, used for geological mapping, and induced-polarisation and electromagnetics, used to define drilling targets. The quality assurance process also identified hundreds of spurious surveys for which there was no useful data. These "zombie" surveys created confusion and disappointment and wasted the time of GSNSW and industry geophysicists searching for non-existent data. Now all surveys with meaningful data can be searched and discovered through MinView using a coherent set of layers for ground geophysics and seismic surveys.

In addition to the updated ground geophysics layers, significant updates to MinView functionality have been implemented to allow direct download of state-wide geophysics merges. The state-wide merges are available both as geolocated images and raster grids, and can be clipped on the fly to an area of interest.

The next major geophysics product release for New South Wales will be an update to the state-wide magnetics merge, scheduled for 1 June 2021, which will include over 100 additional company surveys. These surveys become open file on this date under the NSW Government legislated sunset clause on data confidentiality, introduced in an Amendment of Mining Regulation 2016. These new data will further improve the quality and resolution of this world-class product. Also, GSNSW will be flying a magnetic and radiometric survey in the Cobar region in the first half of 2021. This survey will improve the data quality in areas currently covered by older surveys and will directly feed into the updated magnetics merge and a new state-wide radiometrics merge planned for late 2021.

The new data layers can be viewed in the MinView portal: https://minview.geoscience.nsw.gov.au/

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There will never be a New Normal: 2020 review

COVID-19 will affect humans for several years

COVID-19 and climate change will ensure we will never have a "new normal". In early January 2021, according to Johns Hopkins University, 90 million people have been infected globally and two million people have died from COVID-19. On top of these numbers, it appears that more infectious variants of the disease are emerging, and the long-term health effects are significant. It has been reported that three-quarters of COVID-19 patients hospitalized in Wuhan between January and May 2020 had at least one persistent symptom six months later.

Globally, COVID-19 continues to attack humans throughout the world, severely limiting travel on both global and national scales and increasing death rates wherever it goes. In Australia, we have been fortunate so far, and have not experienced the high infection and death rates experienced in Europe and the Americas. Our weakness has been our quarantine facilities and our delays in the mandatory wearing of masks.

In retrospect, it was easy to see the weakness in the quarantine system. Firstly, although the Australian Government is responsible for quarantine the management of the system was delegated to the States and Territories. Secondly, those enforcing the quarantine were usually poorly paid unskilled workers.

No wonder we had problems!

How COVID affected our resource companies

So how has COVID-19 affected the resource companies in 2020? Let's start by looking at the prices of four key commodities: gold, oil, iron ore and coal (see Figure 1).

Prices for gold and iron ore continued to rise steadily during 2020. Gold increased by 24% over the year from $1529 to $1900/per oz and iron ore by 55% from $94 to $146/t. The price for thermal coal is interesting. It continued its steady decline, to $50/t in August. Then China blocked imports from Australia, and the price rose to $76/t in December (a lose-lose situation?). The oil price was hit hard. Remember it was in negative territory for short time in April. As you can see in Figure 1, it is starting to recover and from a monthly low of $17/bl in May 2020 it was back to $47/bl at the end of 2020. At the start of the year, it was at $60/bl, a wild ride indeed.

The price of the commodities should affect the effectiveness of our resource companies. Table 1 shows how the value of the main resource-listed companies in the top 150 ASX fared during 2020.

The numbers in the table are in $A billions and they show the percentage changes in market value during 2020, and how these compare with the 2019 results. The companies have been grouped according to their main commodity interest.

The three largest companies relied on iron ore prices. Note how Fortescue is now listed as the second largest resource company, and Rio has been relegated to third place.

The gold sector has had more rationalisation in 2020 and Ocean Gold, St Barbara and Regis Resources are no longer listed in the top 150 companies. The production numbers of gold for 2020 are not yet available, but 2019 turned out to be a record year with a production of 325 t. This is below only Russia with 330 t and China with 383 t (https://www.gold.org/goldhub/data/historical-mine-production).

As you can see in Table 1, the petroleum companies were hit hard by the drop in the oil price. The loss in market capital by the top six companies was about $28 billion. Recovery is expected in 2021, but the $100 price per barrel mark is most unlikely.

For those in the coal business, the situation continues to be gloomy. As global warming is now a real concern, several countries are abandoning coal

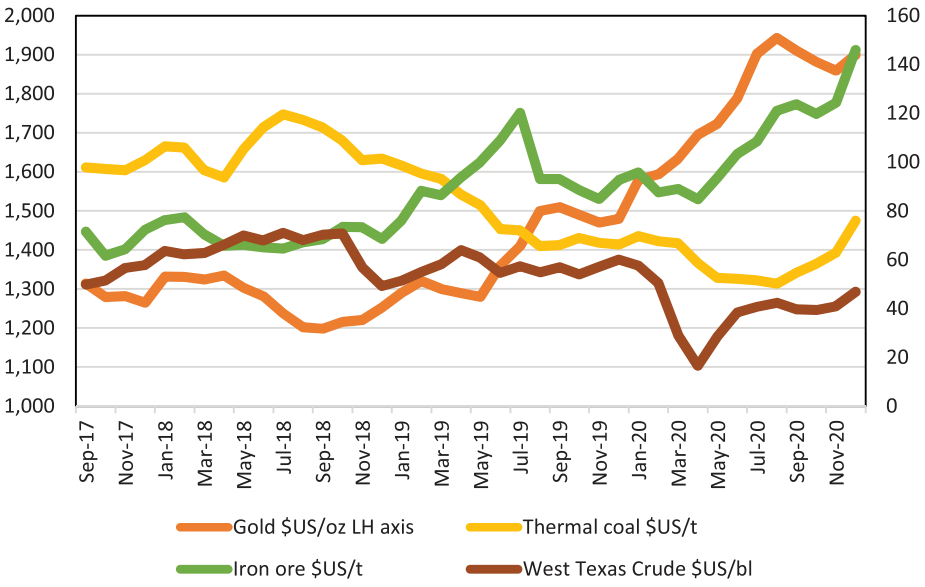

Figure 1. *Prices in $US for gold (LH axis), petroleum, iron ore and thermal coal (RH axis) for 2017-20.*

Table 1. Market capital changes in 2020

	Jan 2020	Dec 2020	Change %	% in 2019
BHP	116.773	124.992	+9	+17
Fortescue	33.098	72.140	+115	+165
Rio	38.058	42.555	+12	+31
Yancoal	3.855	3.195	–17	–25
Woodside	32.763	21.881	–33	+12
Santos	17.518	13.060	–25	+53
Origin	15.146	8.383	–45	+33
Oil Search	11.420	7.708	–33	+4
Beach	5.930	4.117	–31	+91
Newcrest	22.780	21.050	–8	+41
Evolution Min	6.363	8.526	+34	–6
Oz Minerals	3.449	6.254	+81	+28
Saracen	3.551	5.261	+48	+52
All Ords	6855	6.851	0	+21
Market Capital	334.46	336.94	+1	+22
Iron ore +other	Coal	Petroleum	Gold	

to generate electricity. In 2020 the coal companies Whitehaven and New Hope dropped out of the top 150 companies and Yancoal's market value dropped by 17 percent. No wonder the market capital of Whitehaven, Yancoal and New Hope has fallen.

The future of our resource sector is uncertain

The Department of Industry's, *Resources and Energy Quarterly for December 2020*, (https://www.industry.gov.au/data-and-publications/resources-and-energy-quarterly-december-2020) contains a treasure trove of information on our resource sector. One of the diagrams is reproduced below, and indicates the importance of China to our prosperity.

The report forecasts our resource exports to be worth $279 billion in 2020–21, and $264 billion in 2021–22. This is down from the record $291

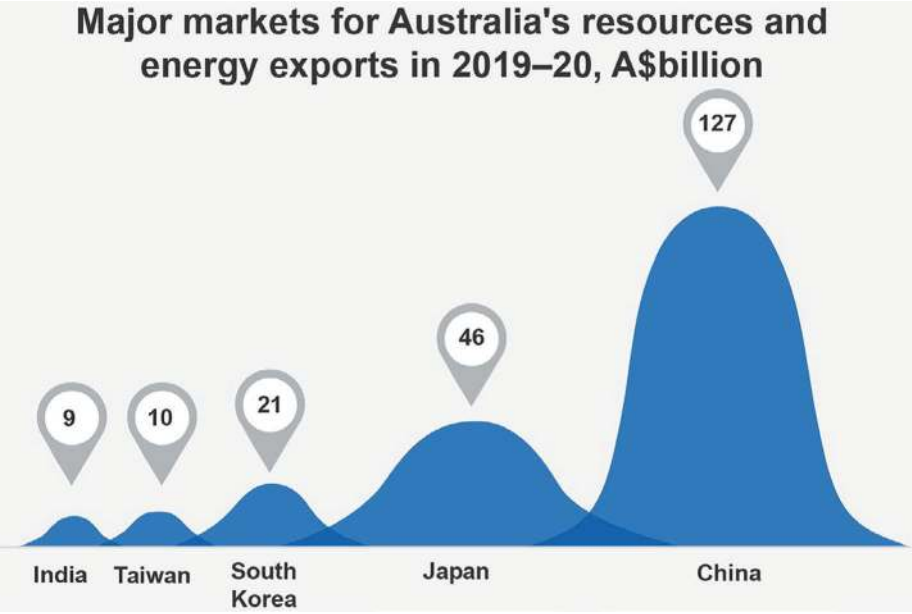

Figure 2. *The value of Australia's exports in the resource and energy sector, clearly showing the importance of maintaining a strong relationship with China. Source: https://www.industry.gov.au/data-and-publications/resources-and-energy-quarterly-december-2020).*

billion in 2019–20, and before our trade war with China.

One of the disturbing parts of this report is the reduction in capital expenditure over the last few years. This includes spending on buildings, machinery, equipment and exploration. The oil and gas sector is now only spending about 10% of what it was spending in 2013-14. The gold sector stands out as a continuing success, and exploration investment has almost doubled in the last three years to reach $350 million per quarter in the third quarter of 2020.

Ultimately our future will depend on politics and COVID-19. Couple these factors with climate change and a New Normal is likely to be unobtainable.

Research efforts by governments and universities should be increased

Expenditure on research by universities increases in 2018

In May 2020 the Australian Bureau of Statistics released its report on *Higher education resources devoted to research and experimental development (R&D)* for 2018 (Table 2). Why we had to wait two years for this information has not been revealed. The ABS only produces these reports every two years in any case, so maybe we should be thankful it is published at all. This situation is indicative of the efficiency-dividend cuts applied annually by recent governments.

Anyway, the report states that:

- Expenditure on R&D performed by Australian higher education organisations during the 2018 calendar year was $12 158 million.
- Higher education expenditure on R&D (HERD) increased by 12% in current price terms and 9% from 2016 when CPI adjustments are applied.
- HERD as a proportion of GDP remained stable at 0.62% over a two-year period.

Table 2. Expenditure on R&D in higher education sector. Source: https://www.abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-higher-education-organisations-australia/latest-release

Year	Current price $m	2018 prices $m	Person years
2008	6 844	8 842	61 773
2010	8 161	9 784	69 392
2012	9 610	10 861	74 669
2014	10 145	10 888	78 038
2016	10 878	11 172	79 008
2018	12 158	12 158	81 717

Government resources for research and experimental development (R&D)

The ABS has also released the numbers for R&D undertaken by governments.

The main findings are that:

- Expenditure on R&D performed by Australian government organisations during the 2018-19 financial year was $3 330 million.
- Commonwealth government organisations contributed $2 110 million (63%), and state and territory government organisations contributed $1,219 million (37%), to total government expenditure on R&D (GOVERD).
- R&D expenditure by Commonwealth government organisations decreased $29 million (1%), while R&D expenditure by State and territory government organisations increased $80 million (7%) compared to 2016-17.
- GOVERD increased 2% in current price terms and remained unchanged in CPI adjusted values between 2016-17 and 2018-19.
- GOVERD as a proportion of GDP decreased from 0.19% in 2016-17 to 0.17% in 2018-19.

Table 3 gives the basic numbers. The decrease in the investment in R&D as a percentage of GDP is a worry. R&D is a long-term investment for our future, and it should be maintained.

We should be doing better.

Table 3. Government resources devoted to R&D. Source: https://www.abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-government-and-private-non-profit-organisations-australia/latest-release

	Australian Government	States		Australian Government	States		
Year	Current price $m	Current price $m	Totals $m	2018—19 price $m	2018 -19 price $m	Totals $m	Person years
2008–09	2252	1169	3420	2793	1450	4243	17 042
2011–12	2462	1123	3549	2800	1296	4096	16 689
2012–13	2345	1381	3725	2594	1528	4123	16 381
2014–15	2257	1072	3329	2347	1114	3461	14 715
2016–17	2139	1140	3279	2172	1158	3330	14 773
2018–19	2110	1219	3330	2110	1219	3330	14 521

Education matters

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Back to school in 2021? Go to universityX

It has been said that "when the economy is in crisis, universities thrive", and during downturns in the natural resources sector geophysicists, among other specialists, have returned to universities to improve their skills and acquire new credentials in order to increase their probability of future successful employment.

However, in the past two years, some safe harbours have been closed. Australian universities have closed their geophysics departments reducing markedly the opportunity to pursue geophysics at the tertiary level. This short communication is design to answer the question: What educational resources are available for geophysicists in 2021?

In 2021 only four universities in Australia offer geophysics degrees, and only two offer master's degrees in geophysics. Curtin University in Western Australia is the only university that offers both an undergraduate degree in applied geology and geophysics and a master's degree in geophysics. The University of Sydney offers an undergraduate degree in geology and and geophysics. Macquarie University offers an undergraduate degree in Advanced Science with a specialisation in geophysics, and complements that with a master's degree in Science Innovation in Geology and Geophysics. The University of Adelaide offers a Graduate Certificate in Petroleum Geology and Geophysics. All these courses are offered on campus as the geophysics curriculum limits possibilities of online learning. What to do if you do not live in Sydney or Perth, the only cities that still run both undergraduate and postgraduate courses in geophysics?

Albert Einstein has been quoted as saying "We cannot solve our problems with the same thinking we used when we created them." Taking a leaf from Albert Einstein's playbook, we should search for alternative, less traditional educational resources. One such modern alternative is online education.

Online education may appear to be a recent invention but, according to Wikipedia, online education started in 1999 when the University of Tübingen in Germany published videos of lectures online for its *timms* initiative (Tübinger Internet Multimedia Server). Arguably the movement was significantly boosted in 2002 when the Massachusetts Institute of Technology (MIT) introduced its OpenCourseWare (OCW) initiative with the aim of publishing all their course materials online and making them widely available. In the same year Carnegie Mellon University started the Open Learning Initiative. The idea was supported by other universities and OCW projects have been launched at Yale, Utah State University, the University of Michigan, and the University of Berkeley.

Currently over 2400 courses at undergraduate and graduate level are available online from MIT alone. These are generally accompanied by homework problems and exams, video lectures, and complete textbooks written by MIT professors. The project is supported by a number of Universities in more than 20 countries. According to the website of the OCW Consortium:

- *An OpenCourseWare is a free and open digital publication of high quality college and university-level educational materials. These materials are organized as courses, and often include course planning materials and evaluation tools as well as thematic content.*
- *OpenCourseWare are free and openly licensed, accessible to anyone, anytime via the internet.*

However, OCW provides neither certification nor access to faculty.

To overcome these two limitations in 2012 MIT and Harvard University launched edX, a massive open online course (MOOC) platform. Using the edX platform, students can communicate with teachers and with other students, sit supervised examinations, and earn academic credits and certificates. EdX is a non-for-profit organisation, offering courses at no charge (but payment might be required to get certification) or for a fraction of the price of on-campus education. Currently, edX embraces 20 million users and offers courses from over 160 universities, including MIT, Harvard and Oxford University, and companies such as Amazon Web Services, Microsoft and Amnesty International. Two Australian universities, Curtin University and The University of Queensland, offer courses in geophysics. The edX platform offers six different types of certification: undergraduate-level MicroBachelors Program, Graduate-level MicroMasters Program and a Professional Certificate. In addition, Executive Education courses are designed for business leaders to help developing strategic skills.

Coursera is another well-known MOOC provider. It was founded in the same year as edX by Andrew Ng and Daphne Koller, computer science professors at Stanford University. Andrew Ng, is famous for his Machine Learning (ML) course, one of the most popular courses on Coursera, in which he explains complex ML concepts in layman's terms. Today Coursera is home to 73 million students and offers over 3900 Courses and Specializations, over 20 degrees and MasterTrack Certificates, and over 13 Professional Certificates. Coursera's strengths lie in the fields of business, personal development, data science and computer science. While the latter two are certainly relevant to practising geophysicists, unfortunately, Coursera does not currently offer any courses in geophysics.

Professional societies also offer online learning. For example, the SEG developed its own SEG on Demand (https://seg.org/Education/SEG-on-Demand) channel that provides records of Virtual Courses, Honorary Lectures, Distinguished Lectures, eLearning Courses, Annual Meeting Technical Program, DISC, and Webinar Recordings. One feature of the SEG's channel is the Geophysics 101 course given by Leon Thomsen, author of the most-cited paper in *Geophysics* (Thomsen, L., 1986. Weak elastic anisotropy. *Geophysics*, **51**, 1954–1966, doi: 10.1190/1.1442051)!

Recently, the EAGE announced the launch of the LearningGeoscience (https://learninggeoscience.org/) initiative. The EAGE offers free eLearning lectures, EAGE Extensive Online Courses with interactive elements on ML for geophysical applications, and real-time instructor-led 2-4 day online courses. EAGE industry partners also offer courses through this platform (for instance, Shell: Geology for non-geologists).

Courses relevant to geophysicists available from the most popular online education providers are summarised in Table 1.

Table 1. Courses relevant to geophysicists available from the most popular online education providers

Source	Certification	Payment	Geophysics
OpenCourseWare https://www.oeconsortium.org/	–	–	+
MOOC edX Platform https://www.edx.org/	+	–/+	+
Coursera https://www.coursera.org/	+	–/+	-
Professional societies SEG on Demand https://seg.org/Education/SEG-on-Demand	–	–/+	+
LearningGeoscience - EAGE https://learninggeoscience.org/	–	–/+	+

So to summarise, although universities and, in particular, geophysics courses in Australian universities are in crisis, opportunities are many and varied for professionals seeking to broaden their skill-base in the online world. It is also apparent that there are opportunities to develop online courses in minerals, energy, and groundwater domains, and the ASEG is eager to support such developments.

Environmental geophysics

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Looking back and looking forward

Welcome readers to this issue's column on geophysics applied to the environment. In this column I would like to look back on 2020 (and I almost promise not to mention COVID or American politics – we'll see how I go), and review what I (and others) think are some of the interesting things that have come out in shallow/environmental geophysics; and then make some predictions for 2021 and beyond. To do this I have polled a few of my contacts in the less deep geophysical world (and one or two who cross over between the two). In alphabetical order, I got input from: David Allen, Kim Frankcombe, Graham Heinson, Ian Moffat, Tim Munday and Greg Street. I polled a total of eight, these are the people who got back to me - pretty good turnout I thought. I also thought that some of these subjects are so interesting that I am likely to go more in-depth on them in future columns.

Based on my informal poll (as well as my own observations over the last year) I would say that the biggest thing that came out of the last year (or so), with the potential to keep giving in 2021 is improvement in mobile, ground-based instrumentation, mostly in the frequency-domain and time-domain electromagnetics (FDEM and TEM) space. To me towed/continuous EM is a little like that actor who makes the sudden breakthrough, and then you look back and they've been around forever. Many of us have been towing high-resolution TEM systems, terrain conductivity meters and the like for quite a while. What's cool is that there are now a number of systems that get both excellent lateral resolution (the "easy" part) but good vertical resolution as well – to > 30 m depth. A partial history of towed land/water based geophysics might go like: Sørensen *et al.* (1995), Snyder *et al.* (2002), Allen and Merrick (2003), Barrett *et al.* (2005), plus a bunch that I have missed. What has got me going in the last year or so is the Aarhus University developed "towed TEM" system (tTEM) (Auken *et al.* 2018) that is starting to get around (Behroozmand *et al.* 2019); and the Loupe system, developed here in Australia by Andrew Duncan and Greg Street (Street *et al.* 2018). These systems (like the mobile TEM system developed by Dave Allen a few years ago) are able to collect data from near the surface (<5 m) to depths >30 m (of course dependent on local noise conditions and resistivity structure of the ground). These systems are better than what I started experimenting with 15 years ago in that these systems are quite mobile, and collect data that is high resolution both vertically, as well as laterally – and go "deep" (deeper anyway).

I had an interesting conversation with Tim Munday on predictions for the upcoming years. Much of what he said tied in with the towed theme that I got into above, but in fact goes further. He suggested that I have a look at some of the developments in the precision agriculture space. He specifically mentioned Geoprospectors (an Austrian company: http://www.geoprospectors.com/gb/products-services/agriculture/), who produce a compact FDEM system that bolts onto the front of an agricultural tractor, collecting and processing FDEM data in very-close-to-real time. A farmer can use the system to collect data over a given field and then, at their leisure, integrate that data set with other data sets (think, for example, high res radiometrics) to make sophisticated maps of soil types, soil saturation potential, etc. to inform future planting, irrigation, etc. Even more interestingly, these systems are able to collect data in real-time and these data may be used on the tractor, to set, e.g. tilling depths on the run.

Kim Frankcombe sent me his thoughts on what he thought were the trends of the last year and what is going to take up his time next year. For Kim the big thing is inverting large data sets (especially 3D inversion) on high-powered Linux boxes. Most of the inversions that we commonly use run only on Windows computers, so he has been spending lots of time modifying "academic" code so that it runs with fewer bugs. He indicates that he is getting good results… He then digressed to wondering about how inversions will be run in the future – will we be going to the cloud-based Software-as-a-Service model? Or just sending our big inversion jobs to a contractor/consultant who has a range of tools available? Or will we still be able to run (afford to own?) stand-alone versions of the products that we know and like? I don't think that we will know the answer to this for a few years to come.

Dave Allen had some interesting insights into the past year (more drought related than the COVID related observations that I expected). In the agricultural area in which he mostly works he found that early in the year he was very busy helping farmers find new groundwater sources. It started to rain in February and the farmers "readjusted priorities" so suddenly there was nearly no more groundwater work. He is hoping that his work will pick up now the farmers have more cash. He also noted a contraction in work with larger engineering companies that he blames on COVID.

And one final news item that I think will be of interest to many: Ian Moffat, lead researcher of a team of investigators from Flinders University, the University of Adelaide and host of others from around the world has just won a Large Infrastructure Equipment and Facilities (LIEF) grant from the Australian Research Council (ARC) to fund the establishment of a National Facility for the 3D Imaging of the Near Surface. Ian says: "Another exciting development in 2020 was the funding of a suite of new equipment for high resolution near surface geophysics through the Australian Research Council LIEF scheme. This will provide Australian researchers with access to next-generation geophysical instruments including a Sensys MX V3 gradiometer array with 16 sensors and a Malå Mira HDR GPR array with 132 500 MHz channels, through the ANSIR scheme via competitive application. This integrated suite of equipment is

currently not available in the Southern Hemisphere and will position Australia at the forefront of the exciting field of near surface geophysics. The expansive size and impressive density of the data that can be collected using these instruments will fundamentally change the research questions that can be asked in the fields of archaeology, earth, environmental and forensic science. Some studies overseas using these instruments show both a 240× increase in productivity and a nearly 4× increase in data resolution on suitable sites so it will be very exciting to see how they are used in Australia". I'm looking forward to seeing this equipment (along with the other equipment that his group at Flinders University has access to) being used in Australia – there should be some exciting results.

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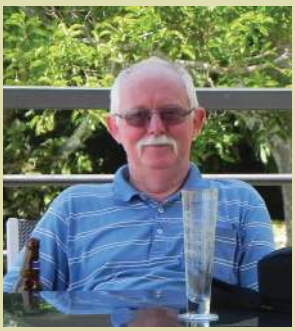
Minerals geophysics



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The Australian land surface

The geology of much of the Australian land surface can be quite different to that of the rest of the world. This impacts strongly on the application of mineral exploration geophysics, as exploration companies discovered when geophysical techniques developed for use in the Northern Hemisphere were first applied to Australian mineral exploration.

Australia is often described as the oldest continent in the world, and it does have some of the world's oldest rocks. But it is really the land surface, parts of which date back more than 90 million years, that is truly ancient. The extremely prolonged exposure of this land surface to weathering has resulted in a distinctive regolith - an indurated crust (variously silcrete, ferricrete, calcrete, etc) overlying a thick zone, often more than 100 metres thick, of intensely weathered material (saprolite). It is this combination of resistant crust and underlying saprolites, now set in an arid environment, which poses particular challenges to the application of mineral geophysics in much of Australia. How does this weathered land surface affect the application of geophysical exploration techniques?

Magnetics – Iron compounds, concentrated in the indurated crust (e.g. ferricrete) by prolonged exposure to weathering, can be converted to highly magnetic maghaemite by the effects of lightning strikes, bushfires, etc. This maghaemite generates strong and sharply erratic magnetic responses, particularly in ground magnetic surveys, which can distort or even obscure the broader coherent magnetic anomaly patterns from basement targets.

On the positive side, in some circumstances these maghaemite responses can be beneficial, for example where surficial iron concentrations reflect underlying geological features of interest such as transgressive structures and shallow palaeo-channels. Maghaemite effects in magnetic survey results can be reduced by filtering the data, by physically raising the sensor further above the land surface in ground surveys, or by using an airborne platform.

Gravity – Intense and prolonged weathering destroys rock fabric, increasing porosity and permeability, which can dramatically lower rock densities. Variations in the thickness and intensity of this weathering will generate unwanted effects in the measured gravity field, the more so because of their relative proximity to the gravity meter. These effects can distort or even obscure the broader coherent gravity anomaly patterns from basement targets.

On the positive side, if enhanced weathering is associated with targeted sulphides or structural fracturing, the resulting lower densities may actually facilitate their detection with gravity. In addition, secondary sulphides generated by weathering-related supergene enrichment may present a positive gravity target in their own right. Weathering-related effects in gravity survey results may be reduced by filtering the data, by incorporating information on the weathering profile such as depths to bedrock derived from other techniques (passive seismic surveys, magnetics, etc.) or by resorting to an airborne platform.

Electromagnetics – Increased porosity and permeability in the weathered zone can dramatically lower the resistivity of the affected rock. In electromagnetic (EM) surveying, this low resistivity layer will absorb much of the EM source field, generating unwanted anomalous responses and limiting the strength of the EM field that penetrates into the basement. Localised variations in the thickness and degree of weathering will further complicate the EM response patterns. In addition, surficial maghaemite concentrations in the indurated crust can generate anomaly-like responses in EM survey results due to superparamagnetic effects.

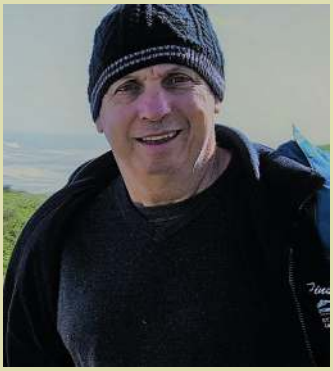
On the positive side, enhanced weathering related to sulphides or structural fracturing, and supergene enrichment, may generate detectable EM targets if other weathering-related responses do not dominate the survey results. Where a conductive basement target is in electrical contact with the weathered zone, current flow in the target, and hence detectability, may be increased. Maghaemite effects in ground EM survey results may be reduced by modifying survey parameters, by changing the relative disposition of the transmitter loop and receiver sensor, or by using an airborne platform.

IP-Resistivity – In the presence of a low resistivity weathered zone, much of the transmitted electric current in an IP-resistivity survey will fail to penetrate an underlying resistive basement, degrading the investigation of basement target zones; associated electromagnetic coupling may also corrupt IP values. As a further complication, a highly resistive capping such as silcrete will make it difficult to inject electric current into the ground, further reducing the strength of any current penetrating into the basement.

On the positive side, enhanced weathering related to sulphides or structural fracturing, and supergene enrichment, may present detectable targets for resistivity if other weathering-related responses do not dominate the survey results; sulphides generated by supergene enrichment are also a potential IP target. Where a low resistivity basement target is in electrical contact with the weathered zone, current flow in the target, and hence resistivity and IP detectability, may be increased. Weathered-zone-related transmitter current injection and penetration problems in IP-resistivity survey results may be reduced by expending extra effort on transmitter electrode preparation to boost current strength, employing a more powerful, higher voltage transmitter, and by utilising a much larger transmitter dipole size (eg pole-dipole array).

In summary, geophysical exploration in deeply weathered environments can be anything but straightforward. Extra thought may be needed to tweak the survey parameters to handle potential difficulties. In some circumstances, if you're lucky, the effects of extreme weathering may even work to your advantage. Good hunting!

Seismic window



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Seismic reflection and hard rocks

I recently caught up with an old mate in Brisbane and he suggested I write an article on HiSeis. "What's that?" I asked. "A company using seismic in the search for minerals. There's some people in Perth doing it" he replied.

I haven't been following the developments in hard rock exploration lately so I set about doing some research. My previous experience was in 1979 when Reg Nelson, who was then at the SA Mines Department, recorded some experimental lines - over Olympic Dam I think. The data could be described as poor, and I never saw a reflection on the paper sections. But that was then, and seismic imaging has progressed significantly in the last 40 years. Using reflection seismology to delineate ore bodies and help plan mine sites is now routine for some companies, and they have been achieving results that were previously not possible. But it has not been a universal embrace of the technology, and others are still struggling to come to terms with the concept. But for those who tried, seismic has been an effective, reliable and efficient method and can provide 3D coverage of an ore body whereas drilling is slow and expensive and only provides information at the well locations.

Using seismic reflection to image hard rocks is not simply a matter of replicating processing procedures in the oil & gas industry. Hard rock exploration has its own set of problems, with the older rocks being inherently homogenous causing a lack of prominent marker horizons, a scattered signal and low signal to noise ratio in an often complex geological setting.

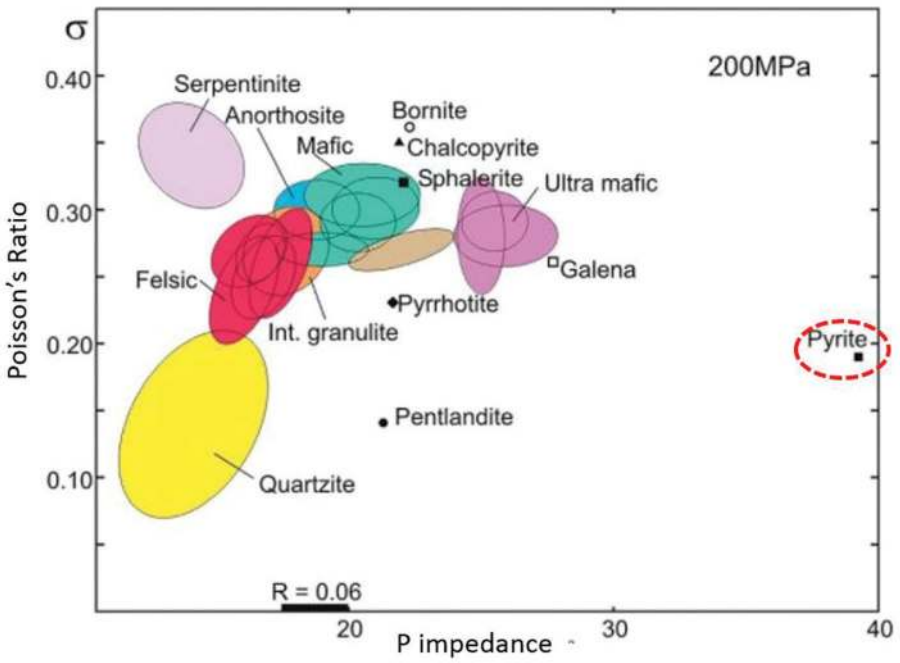

Figure 1: *P impedance vs Poisson's ratio cross plot showing separation of various minerals (modified from Heureux et al, 2005).*

A Canadian group (https://csegrecorder.com/articles/view/3d-seismic-exploration-for-mineral-deposits-in-hardrock-environments) has found that massive sulphides have an Amplitude Variation with angle Offset (AVO) response similar to hydrocarbon sands, so they have found bright spot technology to be useful. It's not that simple though, and like oil and gas sands, the velocity and density within a sulphide deposit varies with mineralogy (Figure 1). For instance, pyrite and felsic minerals increase velocity as density increases but chalcopyrite, sphalerite and pyrrhotite decrease in velocity as density increases. Figure 1 shows the impedance and Poisson's ratio of several minerals, with a clear separation between pyrite and other minerals. But most of the minerals have a similar P impedance and Poisson's ratio can be used to separate the various mineralogies. Poisson's ratio utilises shear wave information which is often azimuth dependent, so surveys need to be designed to sample all azimuths.

HiSeis, the company, is based in Subiaco, Perth, and utilises modern equipment and tools such as VSPs and tomography to produce high quality images of the subsurface. The detail at depths up to 2 km cannot be provided by any other method. They have worked hard to optimise the entire workflow from survey design, acquisition, processing and interpretation and developed unique tools.

There are some well respected names behind this push into hard rock seismic, with several projects conducted by Curtin University until the technology was spun off as HiSeis in 2009 under the guidance of Anton Kepic and Milovan Urosevic.

I am no longer a sceptic and my next step is to actually see what the seismic looks like and how it has helped my hard rock cousins.

Reference

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Editor's note: HiSeis is an ASEG Corporate Plus Sponsor

Data trends

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Point gridding revisited

I have prepared some GIS Python code to follow up on my last column in *Preview* and to help the time consuming job of regularizing irregular points (Table 1). The code uses a "layer" or shape file to iteratively create multiple sets of points with half the spacing of the previous iteration. The code is for ESRI ArcGIS™ but I will try to point to similar QGIS functions.

The code below is just a copy of the Fishnet function help file code with a few extra variables and a while loop. If you want to add to your ArcGIS toolbox, the parameters are

- Layer – file name (a layer or shapefile type)
- Folder – the output folder for all files produced (Folder type)
- Initial Spacing – the largest initial spacing between points (type Any Value)
- Iterations – how many generations of point sets to make (type Any Value)

The user sets the initial spacing between points and how many iterations of point sets with decreasing spacing to write to the output folder. The Create Fishnet function is the easiest way to make a set of points the same area as the target area. I have not identified the equivalent in QGIS yet. I found Create Fishnet needed a bit of help ensuring all data sets have points that overlap, and hence the need for code. The variable OriginMod moves the bottom left hand starting origin for each iteration.

A test was run using 3 overlapping surveys (Figure 1) where the largest spacing is 250 m. An initial spacing of 500 m was chosen and run for three iterations to produce regular points (Figure 2).

Assigning a value to each point is data dependent and philosophical so I have not included a method in the script. The process is quite easy in modern GIS packages with the very easy to use Spatial Join (ArcGIS and QGIS) set to assign the nearest value within a search radius. However, searching only that far often leaves points null. A wider search

Figure 1. *Gravity survey points of three surveys over the Andamooka area demonstrating the irregular points common to exploring. Surveys are 1980R7, 2006A8 and 2010A stretched by Bouguer Anomaly values. Surveys were downloaded from the SARIG website (https://map.sarig.sa.gov.au/).*

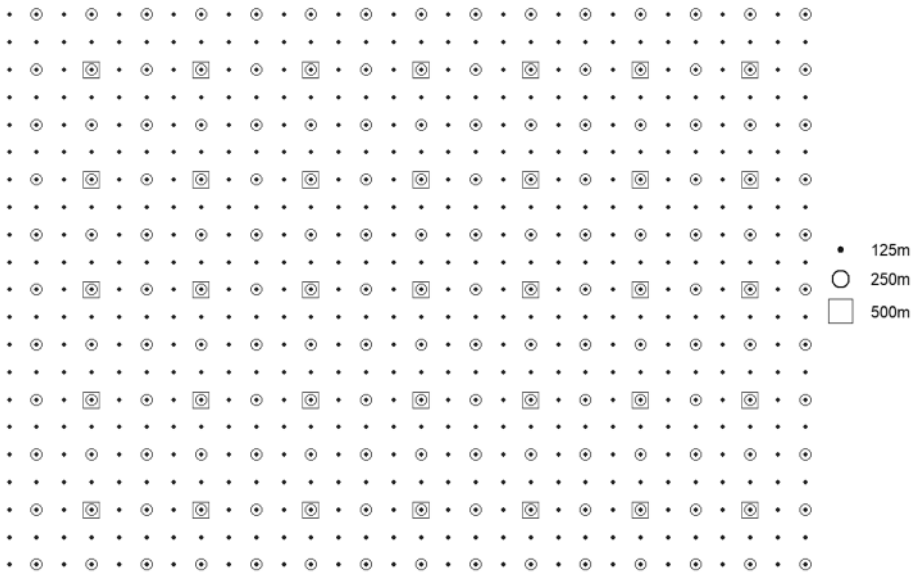

Figure 2. *Regular grids created using the attached code. Three sets of points were iteratively created with half the point spacing of the last – 500 m (square), 250 m (circle) and 125 m (dots).*

poses various potential problems such as a value repeating across data sets but drifting towards its true location in the incrementally closer spaced points sets. The result may be a series of inadvertent linear features tracing through our regular points.

Coarse scale grids might benefit from weighted distance or geostatistical search neighbourhoods to create an averaged point value that better accommodate the original points of more detailed point data. You might change the radius or search shape with scale too.

Hopefully I will have equally simple code to integrate the pseudostations in my next column.

Table 1. ArcGIS Python code example for constructing datasets of increasing point density

```
import arcpy, os, sys
lyr = arcpy.GetParameter(0)
arcpy.env.Workspace = arcpy.GetParameterAsText(1)
StartSpacing = arcpy.GetParameterAsText(2)
StartSpacing = str(float(StartSpacing) * 2)
iterations = int(arcpy.GetParameterAsText(3))

while iterations > 0:
    StartSpacing = str(float(StartSpacing) / 2)
    OriginMod = float(StartSpacing)/2
    outName = arcpy.env.Workspace + "\\" + lyr.name + "_" + StartSpacing.replace(".", '_') + ".shp"
    desc = arcpy.Describe(lyr)
    originCoordinate = str(desc.extent.XMin + OriginModifier) + ' ' + str(desc.extent.YMin + OriginMod)
    oppositeCoorner = str(desc.extent.XMax) + ' ' + str(desc.extent.YMax)
    yAxisCoordinate = str(desc.extent.XMin + OriginModifier) + ' ' + str(desc.extent.YMin + OriginMod + 10)
    cellSizeWidth = StartSpacing
    cellSizeHeight = StartSpacing
    numRows = ""
    numColumns = ""
    labels = 'LABELS'
    templateExtent = lyr
    geometryType = 'POLYGON'
    arcpy.CreateFishnet_management(outName, originCoordinate, yAxisCoordinate, cellSizeWidth, cellSizeHeight, numRows,
    numColumns, oppositeCoorner, labels, templateExtent, geometryType)
    iterations = iterations – 1
```

Webwaves

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Cached webpages

Welcome to the first *Webwaves* of '21. In this edition we are having a look at various methods of viewing cached or historic versions of webpages. Cached pages are useful: they provide redundancy in accessing a webpage at times of high congestion and allow you to visit a website that has been taken down.

The cached pages that we are discussing here are those that are stored on the search engine servers and not those that are stored in the local cache in the web browser. Search engines regularly cache webpages to manage web traffic and provide access to pages that are no longer available.

There are various ways to find cached or historic pages, depending on the browser and search engine being used. I will run through some easy ways to do this, using both Google and DuckDuckGo. Google provides direct access to the cached webpages through their Google search engine, while with DuckDuckGo we use their !bangs - these are shortcuts that allow users to search for results in other sites and services.

For users of Google Chrome or with Google as a main search engine, a very easy method exists for viewing a cached webpage. By entering cache:webpage (e.g. cache:https://aseg.org.au) you will be taken to the cached version of the ASEG webpage. The page that is loaded is the version saved on Google's servers and used for indexing and search. DuckDuckGo users can easily access these from the search engine with the !cache bang (e.g. !cache https://aseg.org.au). The top of the page will inform the user that they are viewing a cached page (Figure 1).

Alternatively, when searching Google, there is an down arrow beside the search result. Clicking on this allows the user to view a cached version of the page (Figure 2).

At times, viewing the latest cached copy is insufficient and an older version of the content is required. For viewing historic webpages, there are other utilities available. The non profit Internet Archive maintains the Wayback Machine https://web.archive.org/. The Wayback Machine stores a library of more than 514 billion webpages as of January 2021.

Figure 1. *Viewing a cached page.*

Figure 2. *Selecting a cached version in Google search.*

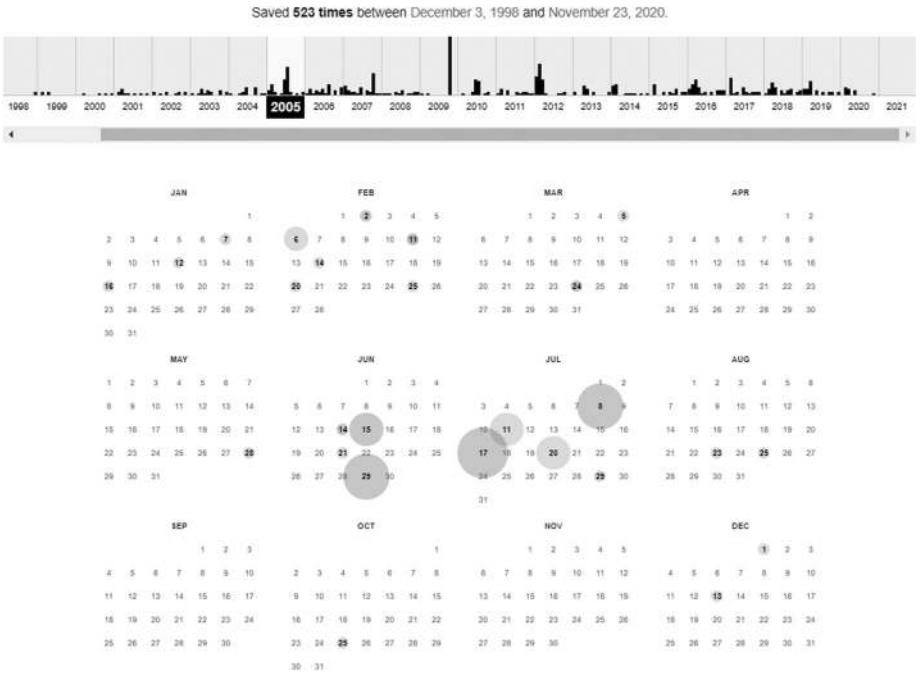

Figure 3. *Calendar view in the Wayback Machine.*

Figure 4. *Wayback Machine archive of ASEG website in 2005.*

DuckDuckGo users can use the !archived bang to directly search the Wayback Machine (!archived aseg.org.au). Searching for a website returns a calendar view with versions of the webpage from the different dates it was saved. Selecting one of the highlighted dates allows the user to view one of the archives.

As of January '21, there have been 523 versions of the ASEG website saved between 3 December 1998 and the present. Figure 4 shows the ASEG website from 2005. This archive is navigable, with access to other pages in the website.

Biological geomagnetic field sensing

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Introduction

Geophysicists are familiar with physical magnetometers that sense the Earth's geomagnetic field, but there are also other sensors of the geomagnetic field which are biological. For at least the past 50 years a particular behaviour of a wide range of animals has been observed, suggestive of an ability to sense Earth's geomagnetic field (hereafter abbreviated as GMF). This can involve orientation to the field direction, and its use in migratory navigation.

The biophysical mechanism for how such sensing is relayed to an animal's brain is still a matter for research. Also, until 2019 there has been no verifiable evidence of this sensing of the GMF in humans. However, a paper published in March 2019 (see following) claims to have found a possible way in which this ability can be true of humans. In general, there has been a recent resurgence in papers on this subject which is generally known as magnetoreception[1].

The observations

One way that sensing the GMF is apparent is that many animals display an ability to navigate to their destination or return home as if they possess a compass. These include homing pigeons (returning from 100 kms away), bees, trout, salmon, monarch butterflies, marine turtles (the latter two over global distances) and more. This can be at night, so navigation is not dependent on sunlight alone.

This involvement with the GMF is, in one way, shown when the field is disturbed, as has been observed with homing pigeons whose headings are erratic during magnetic storms (see Figure 1)[2]. Also, in the presence of an artificial field in the laboratory some animals track the change in direction of the

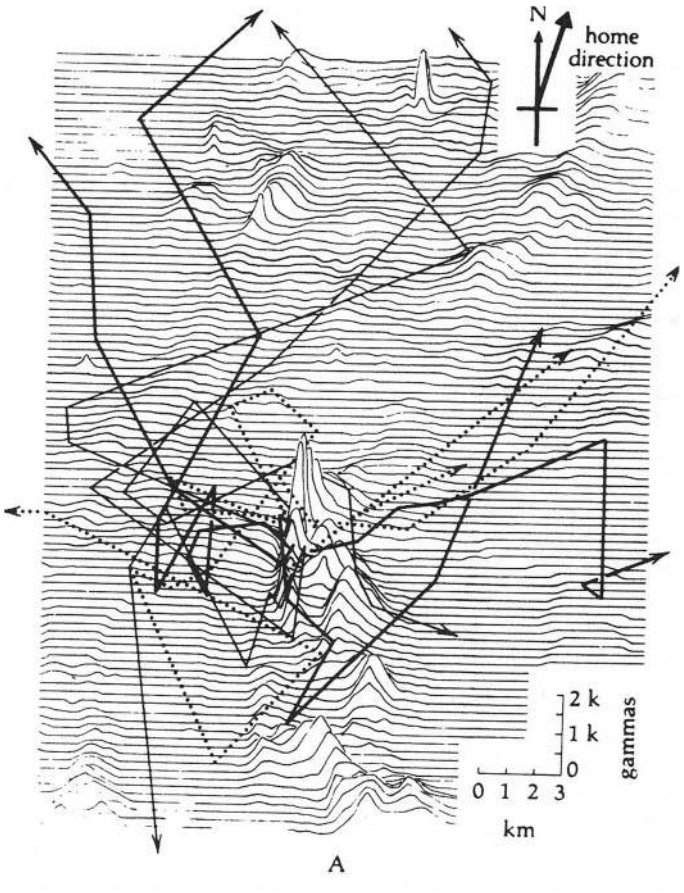

Figure 1. *The directions of pigeons no longer have the heading of "home" after crossing magnetic anomalies shown in the magnetic profiles of the area (from Kirschvink et al, 1985).*

field, showing that they use the field for orientation. Monarch butterflies, in particular, have been shown to react in this way.

In 1975 in a particular type of bacteria now well known as 'magnetotactic bacteria' was described. Biologically developed magnetic material, called magnetosomes, is enclosed in the bacteria's cells. These magnetosomes align with the GMF and the alignment can be changed in the presence of a bar magnet. Figure 2 shows similar magnetosomes from the sockeye salmon.

Sensing the field in ways other than directly with magnetosomes includes the very first observation more than 50 years ago in India that termites align their mounds in the GMF direction.

What is the sensor?

As to the nature of the sensor involved in these situations, two main theories have been proposed for some decades. One relates to the magnetically responsive material found to exist in most animals including in the beaks of birds, the noses of fish, and the brains of whales and dolphins. Bees retain such material in their abdomen, while butterflies have it in their thorax. Monarch butterflies, which migrate thousands of kilometres, have substantially more magnetic material than other butterflies.

[1] 1. A small selection from a great number of references are; Wikipedia: 'Magnetoreception' (Up-dated in 2019) with 72 references; Wiltschko, F. R. & Wiltschko, W. 2012. "Chapter 8 - Magnetoreception". In Carlos López-Larrea (ed) *Sensing in Nature. Advances in Experimental Medicine and Biology*. **739**. Springer. doi:10.1007/978-1-4614-1704-0 ; and more amusingly, Nicholls, H., 2016, Animal Magnetism. *New Scientist*, 17-31 December, 44-46.

[2] Pigeon racers know not to hold meetings when the GMF is disturbed.

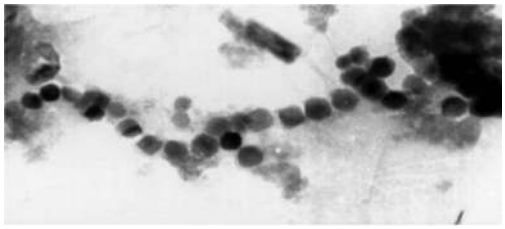

Figure 2. *An electron micrograph image of the chains of magnetosomes from a sockeye salmon that are similar to those of magnetotactic bacteria (from Mann et al, 1988).*

Living cells have the ability to build these nanocrystals of magnetic material as a form of biogenetic ferromagnetism. X-ray absorption spectroscopy analyses show it to be mostly iron oxides. The microscopic amounts of material involved are detected by Superconducting Quantum Interference Device (SQUID) magnetometers and observed by electron microscopes[3]. Is this magnetic material the sensor of the GMF? Possibly, but it is still not known how these cells produce neural signals in the organism's brain. In the case of homing pigeons, the magnetic material in the beaks is less than 3 nm in size and dispersed in a fluid. This fluid sac is elongated in one direction, and it is thought that pressure changes caused by its direction relative to the GMF are sensed by the pigeon's nervous system.

In 2015 a team of neuroscientists at the University of Texas, Austin reported on their study of the particular nematode *Caenorhaditis elegans*. This worm is known for its ability to align with the GMF and to track it if the direction is altered. They discovered in the head of the worm an unusual micro-structure at the tip of a neuron which they believed to be its GMF sensor. They noted that when this feature is removed by genetic engineering, *C. elegans* becomes disoriented (Vidal-Gadea, *et al*, 2015 and Bainbridge, *et al*, 2016). As some other animals like butterflies and birds have similar brain structures, the research team suggested it is possible that they may also have this feature.

The other general theory for the existence of a sensor, a more chemically based theory known as the 'radical-pair' hypothesis, was first suggested in 1978. It relates to a molecule that contains two unpaired electrons that are seen to be sensitive to changes in the relatively weak GMF. Rodgers and Hore (2009) affirmed that the radical-pair mechanism is currently the only plausible way in which weak magnetic fields can affect a chemical reaction[4]. Such a molecule sensitive to the GMF is the cryptochrome protein, which exists in many animals including the monarch butterfly, the common fruit fly and the retinas of many migratory birds. The location in the retina gives a direct connection to the brain through the optic nerve. Specifically, in European robins the molecule is found in the right eye which, if covered, causes the bird to become disoriented. Could the cryptochrome molecule be a sensor?

As many animals and, in particular, birds and monarch butterflies have magnetic material and cryptochromes, both sensor mechanisms may be employed together. Many workers in this field propose that for birds the magnetic material in the bird's beak measures the strength of the GMF and hence senses position, while their cryptochromes provide the directional information (Wiltschko and Wiltschko, 2019).

A recent paper by Natan and Vortman (2017) claims to have found a mechanism for the elusive connection between the sensor and the brain by proposing the involvement of the GMF sensing ability of magnetotactic bacteria, which they note would otherwise appear to have no "adaptive value". They propose a mutualism or symbiosis between it and the particular animal concerned to provide a connection that gives the animal a sensor and the bacteria a value, or purpose. However, a follow-up paper by Natan *et al* (2020) published in the prestigious *Philosophical Transactions of the Royal Society B*, sought to address the "criticism and support" raised by their hypothesis presented in the previous paper. Finally, they "suggest the future research directions required to confirm or refute the possibility of symbiotic magnetic sensing" and admit that they have not yet found "the mechanism by which the host and the bacteria communicate"! It would seem that this idea of symbiosis using magnetotactic bacteria has much scope for further investigation.

The situation with humans

If a magnetic sense is common in the animal kingdom, then why not in humans? Did we once have this ability and then gradually lose it over time? Or, is it still present but suppressed below the current level of detection? To research this question requires testing the subject when the GMF is varied or non-existent, as is done more easily with other animals. Some researchers suggest that human health and behaviour are related to the changes in GMF, possibly without our being conscious of the phenomenon. One study (Nicholls, 2016) found an increase in suicides during magnetic storms. Another found that blood pressure also varies with activity in the GMF. Does this activity cause the headaches felt by some at this time? Finally, some people believe they sleep better when aligned to the field.

Biologically developed magnetic material was first detected in humans in 1992; in the brain, heart, spleen and liver. SQUID magnetometers have detected particles weighing only a few nanograms and less than one ppm in volume[5]. Cryptochromes, the chemical sensors, are also found in the retinas of humans, which are directly connected to the brain. Thus, both proposals for a sensing mechanism could apply to humans.

In a recent paper by Gilder *et al* (2018), the magnetic intensity of brain tissue was closely mapped on seven laboratory specimens[6]. The results from over 800 separate brain samples were measured with a magnetometer and shown as contours of magnetic intensity (see one result in Figure 3). The results are independent of the sex and the various ages of the specimens. Some areas were found to be more magnetic than others. In particular, the cerebellum and the brain stem were found to be twice as magnetic as the upper regions of the brain. The authors thought this could have evolutionary significance.

In an even more recent paper by Wang *et al* (2019), changes to human alpha brain waves were observed in response to a changing magnetic field. Thirty four participants were individually enclosed in a Faraday cage that enabled the

[3]There is a branch of this study called 'biomineralisation' and textbooks published on it, include Kirschvink, et al., (1985) and Evans and Heller (2003).

[4]This paper has 109 references.

[5]A general reference for this topic is found by searching: 'brain magnetism' which yields many references including some mentioned here.

[6]Stuart Gilder, one of the authors, is a geophysicist who normally studies palaeomagnetism of rocks.

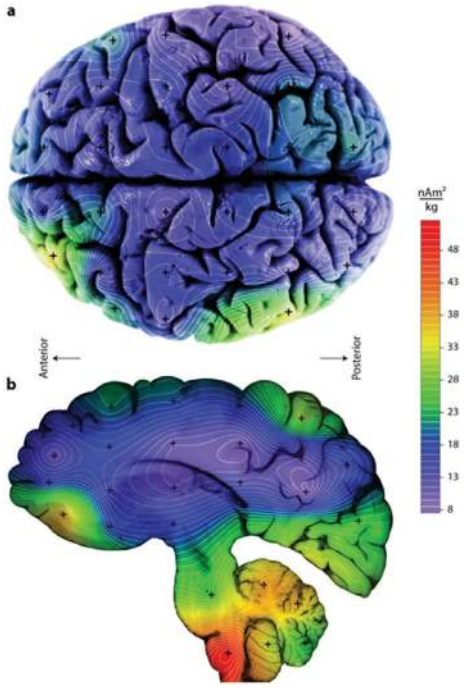

Figure 3. *A top and side view of one of the brains mapped showing contour lines and areas of intensity strongest at the base of the stem (from Gilder et al, 2018).*

magnetic field to be manipulated while the brain waves were monitored by EEG. Changes in the activity in the brain were mapped in detail with 64 electrodes. Movement of volunteers was avoided to prevent spurious brain signals related to that. Manipulations of the field were thus oblivious to the participants and the strength of the field was of the order of the Earth's field. In all cases, as the EEG data revealed, the response to field changes were directly observed by the brain, leaving no doubt that a connection was being made. However, the participants were completely unaware of the field changes and their brain responses. Thus, there is evidence that these particular participants, at least, have magnetic sensors subconsciously sending signals to their brains[7].

It is of interest that changes in brainwave patterns were different among participants. Does this suggest that some people are more responsive to the GMF than others? Such differences between individuals may be something that could be exploited in future.

Also, it should be noted that these findings have been of interest to military organisations. In particular, the research described above was partly funded by DARPA, the research and development agency of the U.S Dept. of Defense.

Concluding remarks

Where possible, I have emphasised the most recent research in this decades-long subject (for example, August 2020) and have also preferred papers from reputable sources (Royal Society of UK and National Academy of Sciences USA).

The author particularly acknowledges the use of previously published material reproduced in Figures 1, 2 and 3. The sources for this material are referenced below.

[7]The authors report that these results have already been replicated using a different group of volunteers and are soon to be published.

Studies in this field span a number of different specialisations, such as magnetobiology as a subset of bioelectromagnetics, which then also includes biomagnetism. A full understanding of the research, therefore, requires a good level of cross-disciplinary knowledge. For example, three of the authors of Wang *et al* (2019), were a neuroengineer, a cognitive neuroscientist and a geophysical biologist.

The findings reported here in relation to the human brains' subconscious reactions to magnetic fields equivalent to the GMF are hopefully the start of further fascinating revelations in this area.

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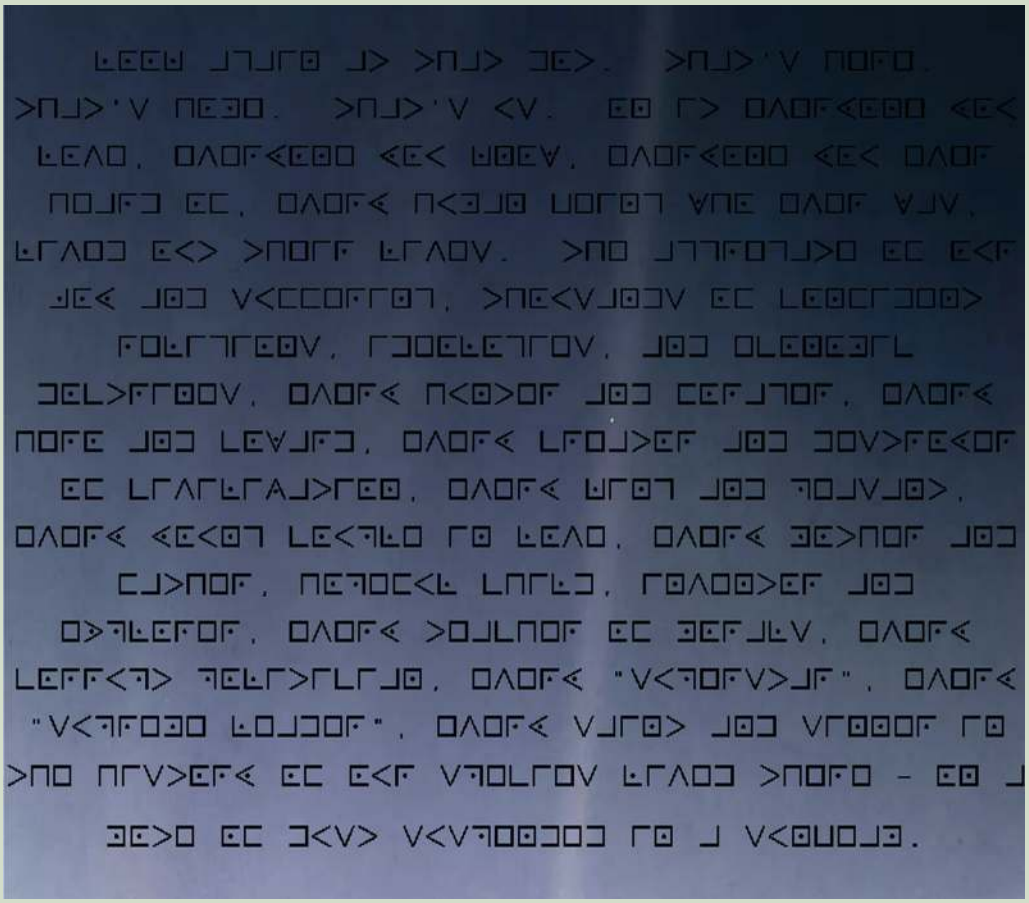
Preview ~~crossword~~ puzzle #12



In the moment, small things can seem so important. After the extraordinary year we've all just had, the above coded message is a reminder of just how small our daily problems and heartbreaks are when we keep things in perspective. Be grateful, try to be kind to each other and enjoy yourself.

Play to win!!

Crack the code and send a copy of the message contained to *previeweditor@aseg.org.au*. The first correct entry received from an ASEG Member will win two Hoyts E- CINEGIFT passes. The answer (and cipher) will be published in the next edition of *Preview.*

Good luck!

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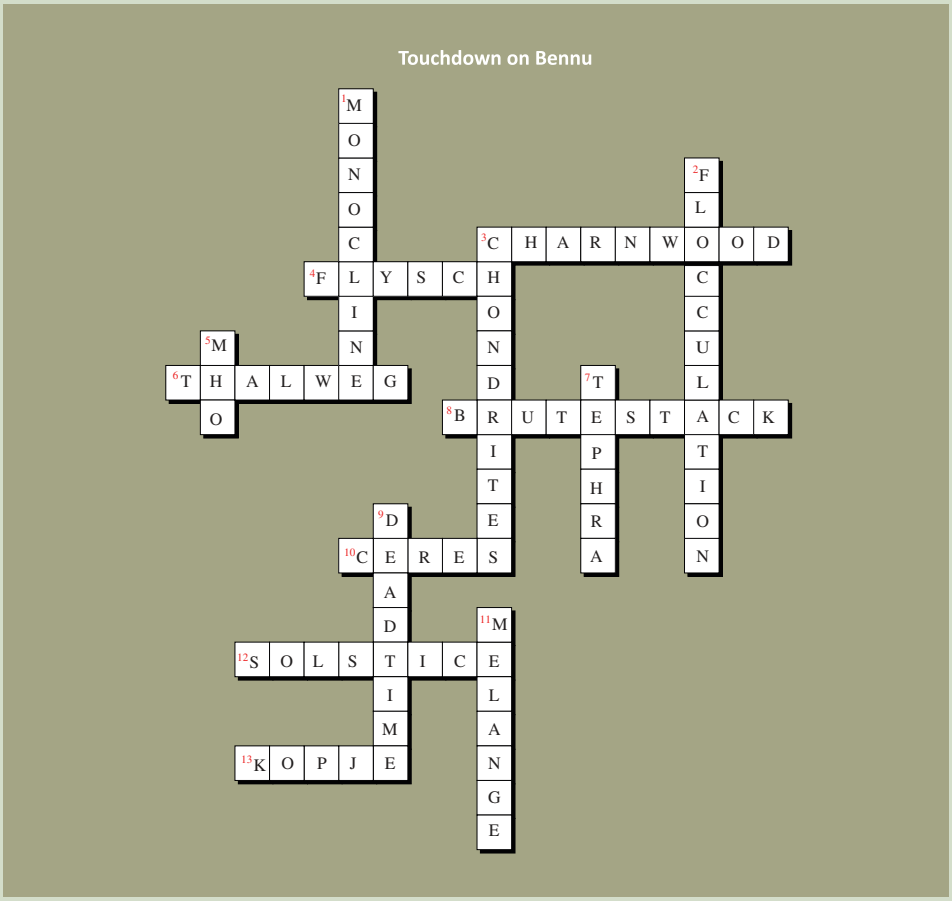
Preview crossword #11 solution



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INSTRUCTIONS FOR APPLICANTS

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3. Attach the appropriate dues and submit the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy of this page for your own records. If payment is to be made by credit card, the application may be sent by fax.

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Organisation		
E-mail		
Phone (W)	Phone (H)	Fax
Mobile		

Section 2. Choice of Membership Grade (Tick one)

❑ Active	Please complete all sections
❑ Associate	Please complete all sections
❑ Graduate	Please complete Active or Associate application and also check this box
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Active – an applicant must be actively engaged in practising or teaching geophysics or a related scientific field. Conditions for Active Membership include a relevant academic qualification. Any person who does not have such qualifications, but who has been actively engaged in the relevant fields of interest of the Society for at least five years, shall also be eligible for Active Membership upon the discretion of the Federal Executive Committee.

Associate – an applicant must be actively interested in the objectives of the Society. Associate Members are automatically eligible for election to Active Membership after five years as an Associate Member.

Graduate – Active or Associate membership is subsidized by 50% for no more than two years after completion of studies. Members accepting the graduate grant are expected to contribute to society activities and publications with the goals of raising their profile in the society and showing ASEG's support of young professionals.

Student – an applicant must be a full-time graduate or undergraduate student in good standing, registered at a recognised university or institute and working towards a degree in geophysics or a related field. Eligibility for Student Membership shall terminate at the close of the calendar year in which the Student Member ceases their graduate or undergraduate studies. The duration of a Student Membership is limited to five years.

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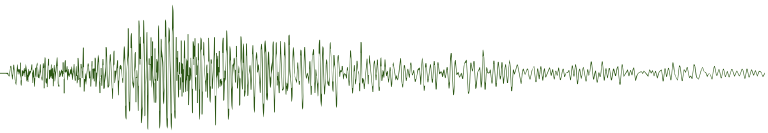
Section 4. Nominators (Must be ACTIVE Members of ASEG)

Nominator	Name	Postal or e-mail address	Phone/Fax
Proposer			
Seconder			



Section 5. Membership of Other Societies

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❑ Education	❑ Consulting	❑ Other _____	

Type of Business:

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❑ I (or my business) am interested in advertising in ASEG's publications.

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I, _____ (name), agree for the Australian Society of Exploration Geophysicists to make all necessary enquiries concerning my application and suitability to become a Member. By lodging this Application and upon being accepted in my membership, I agree to be bound by the Constitution of the Australian Society of Exploration Geophysicists, including its ethical and professional standards.

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INSTRUCTIONS FOR APPLICANTS

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2. Fill out the application form, ensuring that your supervisor signs Section 2.
3. Submit the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy of this page for your own records.

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Surname		Date of Birth
Given Names		
Mr / Mrs / Miss / Ms / Other (list)		
Address		
	State	Post Code
E-mail		
Phone (W)	Phone (H)	Fax (W)
Mobile		

Section 2. Student Declaration

Institution	
Department	
Major Subject	Expected Year for completion of studies
Supervisor/Lecturer	Supervisor Signature

Section 3 Membership Grade

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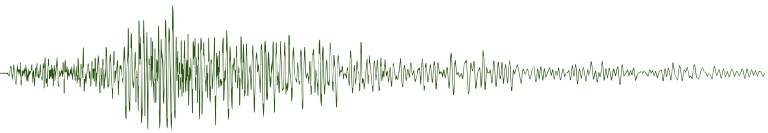

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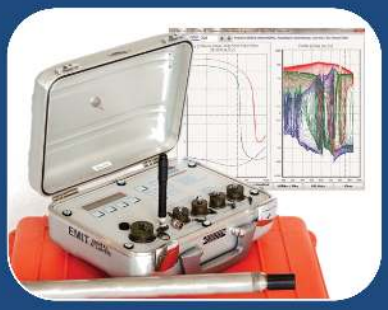

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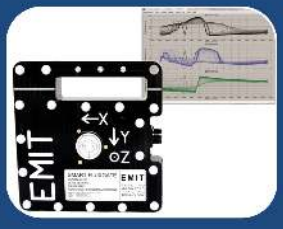

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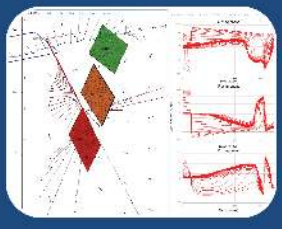

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